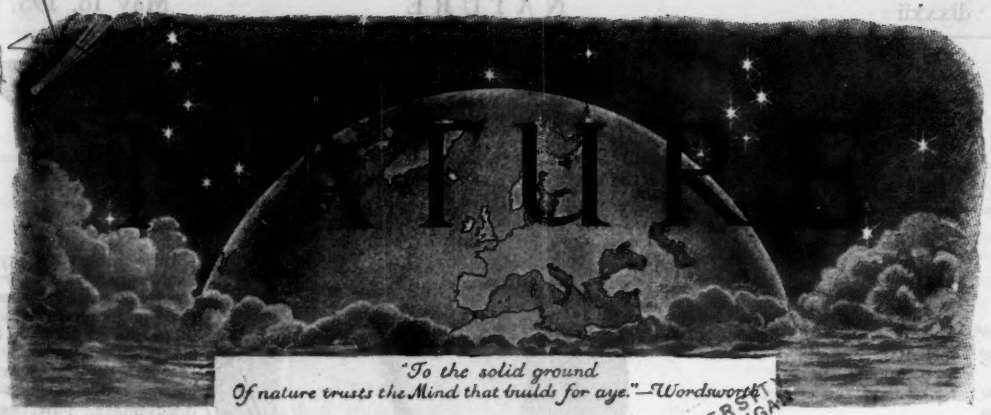

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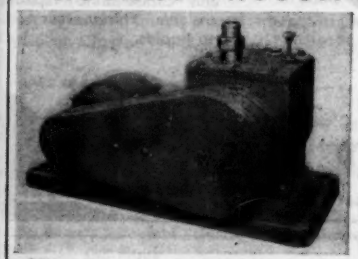

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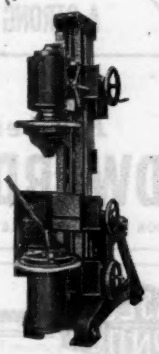

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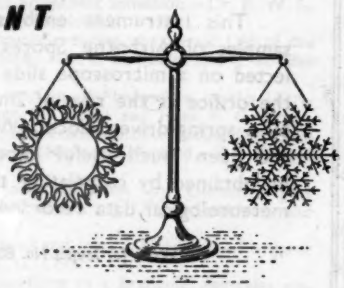

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NATURE

No. 4568 SATURDAY, MAY 18, 1957 Vol. 179

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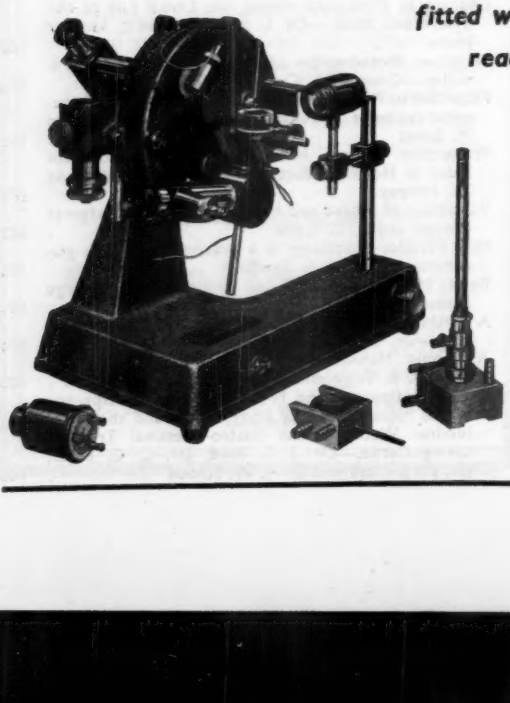

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EDUCATION FOR THE SCIENTIFIC AND TECHNOLOGICAL AGE

IN a debate on nuclear energy and scientific and technical education in the House of Commons on March 22, a resolution, moved by Mr. B. T. Parkin and seconded by Mr. A. Albu, was adopted, welcoming the announcement of an expanded programme of capital investment in the production of power from atomic sources, and associating it with the expansion of scientific and technical education at all levels. In replying for the Government, the Parliamentary Secretary to the Ministry of Education, Sir Edward Boyle, said that the Government was very happy to accept the motion, and agreed that it was, as Mr. Parkin had pointed out, not simply a matter of extra demands for the nuclear programme, but also of the effect of total demands for technical education. That was already under discussion between the Ministry, the University Grants Committee and the Atomic Energy Authority, for to a large extent the new power station programme would make demands on the ordinary engineering man-power of the country. So far, all needs for further specialist education in the industrial aspects of nuclear science, he said, are being met at the two reactor schools of the Authority and by courses provided in universities and technical colleges; but the Government is taking fully into account the special needs which will arise from this increased power programme, and arrangements are being made for continuing close consultation with the Authority so that the universities and colleges are ready to meet new needs as they arise.

Referring then to Britain's dependence on skilled man-power generally, Sir Edward Boyle reminded the House of figures given in the report on scientific and engineering man-power published last autumn. The industries in which two-thirds of the scientists and engineers in Britain are concentrated—but accounting for only three-tenths of the total of employees—are the expanding sectors of our economy on which the export trade, and therefore our standard of living, so very largely depends. Furthermore, it is not simply a matter of producing sufficient first-class men but also of producing sufficient technicians and craftsmen. These will have to come from the technical colleges, and it is possible that in a few years time the most critical shortage may be not so much in scientists or technologists as in technicians.

First, however, Sir Edward Boyle emphasized the important part which the schools of Britain must play in our system of technical education—by which he appeared to mean the production of both technicians and technologists as well as scientists. While the sixth forms of the grammar schools at present provide annually about 7,000 out of the 10,000 scientists and technologists, and should supply at least 11,000 out of the 20,000 proposed for the 'sixties, the secondary modern schools are already making an important contribution. In all secondary schools there has been an increase of almost 50 per cent in the numbers of those obtaining passes at the 'ordinary' level in mathematics and physics at the General Certificate of Education between 1952 and 1956, and about 60 per cent of boys in the sixth forms of maintained grammar schools, and 50 per cent of those in public schools are to-day studying principally a scientific subject. The number of teachers with degrees in mathematics and science in maintained grammar and secondary schools has recently risen; but the increase has not kept pace with the demand and there has also been a fall in quality.

Sir Edward recognizes that this may be the greatest difficulty in the whole problem of scientific and technical education in Britain, and he claimed that steps have already been taken to improve the situation; thus he mentioned, besides indefinite deferment of national service, the arrangement by which teachers are attached for periods to the Royal Aircraft Establishment at Farnborough and the Royal Radar Establishment at Malvern. More accommodation and scientific equipment are also needed, however, and Sir Edward paid tribute to the assistance given by the Industrial Fund for the Advancement of Scientific Education in Schools. Since the War, equipment amounting in value to more than £2·5 million has been provided, divided almost equally between the thousand laboratories built in grammar and secondary schools at a cost of £4·5 million and the 2,250 laboratories provided in modern schools at a cost of £9 million. He agreed that the teacher-training colleges are not so fully staffed for teaching mathematics and science as could be wished; but, he said, there has been a 10 per cent increase in the current academic year in the number of training college lecturers teaching mathematics and an increase in science lecturers. In the colleges, there are special two-year courses in science, integrated and followed continuously by a third-year course wholly in the study of science.

Before referring to the work of the universities and technical colleges, Sir Edward emphasized the importance of the link between school and further education, particularly the difficulty of linking full-time courses in schools, from which pupils come at varying ages from fifteen to nineteen and with varying academic attainments, with the vocational courses in the technical colleges. The important point, he said, is to ensure that there is adequate continuity of purpose and knowledge between the staffs of the technical colleges and the secondary schools. While the links between the secondary technical schools and the colleges are usually good, a closer link between the technical colleges and the grammar schools is required to avoid serious wastage of potential technologists. Much could be done here, and he warmly commended the experiment of a course in technical

colleges for science masters of secondary modern schools.

As regards the universities, Sir Edward Boyle did not add much to the statement made by the Chancellor of the Exchequer on March 28, or the recent interim report on university development in Britain from the University Grants Committee, beyond pointing out that at present science and technology are developing considerably faster than the other sides of the universities. The rationalization of the system of technical education in Britain, however, is a major task of the Ministry, and since the White Paper was published a year ago the Ministry has been attempting to classify the 550 colleges in England and Wales in four categories, ranging from purely local colleges to colleges of advanced technology. The Ministry is also trying to strengthen the arrangements for the organization of colleges and courses, and in England and Wales alone has already authorized more than half of a programme of new building and equipment costing £85 million to be put in hand by 1960–61. A report on the training and recruitment of teachers for technical colleges is expected shortly, but it has not proved easy to transform the eight colleges provisionally designated into colleges of advanced technology. Nevertheless, Sir Edward hoped that the number of students at these colleges would be increased from 4,000 to 8,000 or 9,000 within the period contemplated by the White Paper. He claimed that the Hives Council will insist on very high standards for its award of the diploma in technology, and he does not think that the work of the universities and of these colleges will overlap or produce too many graduates. He hopes that by the late 'sixties the technical colleges will be supplying at least 5,000 a year of the 10,000 technologists at which we are aiming. He did not give any figures for the output of technicians and craftsmen; but in concluding, he referred to the importance of public opinion if more use is to be made of women as scientists, technologists and technicians, and if our objectives in technical education are to be achieved.

Whether or not Sir Edward Boyle in this speech entirely dispelled the misgivings freely expressed by Mr. Parkin, Mr. Albu, Mr. Geoffrey Lloyd and others as to the effect of the nuclear-power programme upon the distribution of the resources in Britain of scientific and technical man-power, it is clear that the Government is alive to the dangers inherent in the situation and is taking some measures to meet those dangers. Some of those risks are clearly inherent in the present arrangement in which the responsibility for higher technological education is still divided between the Lord President of the Council, the Chancellor of the Exchequer (through the University Grants Committee) and the Minister of Education; and the confusion between technical and technological education persists. Sir Edward's speech gave no assurance that the Government's plans will provide anything like the ratio of five technicians for every technologist which Mr. Lloyd and Mr. Albu insisted is required. It is apparent that an impartial examination would reveal other weaknesses in the present system which are receiving no attention.

Some of these weaknesses may well receive criticism when Dr. Willis Jackson's committee issues its report on the training and supply of teachers for technical colleges; it is inconceivable that no comment will be made on the implications for the technical colleges of the new scales of salaries for university staffs. That, however, is only one indication of the way in which a really far-reaching inquiry into the use of scientific and technical man-power might yield invaluable recommendations, though whether the Government would be prepared to accept the searching criticism which would be forthcoming is doubtful. So far, indeed, it has preferred to allow waste to continue rather than incur the opposition from vested interests involved in their elimination in accordance with recommendations already before it; though Lord Hailsham at least has recognized that without some give and take no real improvement in technical education is possible. The country cannot continue indefinitely to fritter away invaluable resources in this manner; this aspect should not be overlooked, for all the admirable efforts, to which Sir Edward referred, now being made to improve the situation. What needs to be emphasized is that such an inquiry, looking at education as a whole and in relation to both the resources and the needs of Britain, like the task of making the general public more aware of the importance of technical and technological education and creating a new attitude to it, is not a political party matter. It requires the support of all who are alive to the dependence of the economy and the whole standard of living in Britain upon the level not only of scientific but also of technical education. There is increasing evidence of much co-operation to that end. Sir Edward Boyle referred with appreciation to the appearance of new periodicals as well as to the Industrial Fund for the Advancement of Scientific Education in Schools, Mr. Lloyd spoke of the way industry is co-operating in Birmingham, Mr. Albu of the provision by Messrs. Vickers, Ltd., of a hall of residence for the Imperial College of Science and Technology, and the debate indicated a large measure of agreement as to the priorities, if not always as to the means to be adopted to implement policy.

As a contribution to the task of public education, the Reith Lectures on "Science and the Nation" which Sir Edward Appleton delivered last winter were timely, the final lecture in which he discussed science and education being perhaps the most important. So far as Parliament is concerned, the debate showed that it is increasingly aware that adaptability is, as Sir Edward Appleton urged, one of the essentials to be fostered in the training of the scientists, and also of the technician and technologist. This is one of the reasons for the insistence on the importance of a general education; and while it is important to encourage more of our most talented young people to take up careers in science and technology, the training they receive must be such as to fit an increasing proportion of them to handle the

human as well as the technical and economic problems with which they are confronted.

If indeed this problem were solved, there would probably be no lack among Ministers and members of Parliament, in the higher ranks of the Civil Service and on the boards and directorates of industry, of a sufficient number, not simply of scientists and technologists of proved administrative competence, but also of administrators capable of appreciating for themselves the importance of scientific and technical factors in a problem or situation. In such conditions, there would probably be little difficulty in working out effective policies for the expansion of technical education at all levels and for keeping educational policy in balance with the resources of Britain and with the demands for trained man-power of all kinds. The primary problem is that of communication, to which compartmentalism of all kinds—whether in the central government, in local government, or in educational institutions—excessive specialization and apathy are the greatest obstacles.

The Minister of Education is evidently determined to deal vigorously with apathy on the part of the public to the extent to which it hinders boys and girls from entering on careers in science and technology and full use being made of the facilities now being provided. Even in that task, he needs all the help that professional institutions and such bodies as the Parliamentary and Scientific Committee can give him; still more, he requires the full co-operation of the schools, the technical colleges and universities, government departments and industry in improving the facilities and making full use of the trained man-power that will be forthcoming. To deal with the neglect of industry and of public bodies to make sufficient use of scientists and technologists and to see that those now employed are used efficiently under appropriate conditions and supported adequately by technicians and craftsmen are more difficult tasks, which under present conditions appear to fall chiefly within the responsibility of the Lord President of the Council. There appears to be a field calling for greater effort and considerable inquiry, if not research; but the content of education in this age of nuclear power and automation also offers a large and urgent field for inquiry at all levels. This applies not merely to the education of the scientist and technologist, the craftsman or technician, but equally to the education of the ordinary citizen, whether he be employed in some unskilled job in office or factory, in agriculture or transport, or in some highly responsible administrative post.

Perhaps the most encouraging feature of the debate is the evidence that this problem of education is beginning to be approached as a whole and not piecemeal. Much, however, remains to be done before full understanding is established and relations between the different sections is sufficiently close to avoid waste and frustration while providing the flexibility upon which the Government rightly insists. There is welcome evidence that the professional institutions themselves are approaching the question of professional training at all levels with fresh minds, for they, too, have an indispensable contribution to make. Above all, there are needed wise vision and clear thinking, the discarding of doctrinaire approaches and preconceived ideas, and the urgency and driving force which come when education is seen as the outstanding weapon for adapting ourselves to meet the challenge of change. The more that education is seen as a single problem and its significance is appreciated—not simply for particular developments like that of nuclear power, but also to the whole economy of Britain and the efficient use of our resources in industry, the public services, defence and welfare—the easier it should become to introduce whatever radical changes may be required in the organization of the education system itself, in that of the central government, or at local government level. There may well be dangers in the system of block grants to local government authorities recently announced, though Lord Hailsham has given emphatic re-assurances to the National Union of Teachers on that point; but at least the system involves a closer association and understanding on the part of the local elector with what is being done in the schools. Without such co-operation and understanding the Government's plans for the expansion of technical education and of university education are unlikely to succeed. Given that co-operation and understanding and goodwill, there should be little difficulty either in making the changes required in organization or institutions, or in the relationships of institutions and departments. Further, co-operation is essential in securing whatever further expansion may prove necessary, either in the universities, the technical colleges and colleges of technology, or in the schools themselves, and the acceptance of the sacrifices in other sectors of the economy that such expansion and the consequent diversion of resources in man-power and materials inevitably entail.

ENCYCLOPÆDIA OF CHEMICAL TECHNOLOGY

Encyclopedia of Chemical Technology

Edited by Raymond E. Kirk and Donald F. Othmer. Vol. 15: Waxes to Zymosterol. Index to Volumes 1–15. Pp. xiv+936. (New York: Interscience Encyclopedia, Inc. Distributed by Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1956.) 30 dollars.

THIS is the last of the fifteen volumes of Kirk and Othmer's "Encyclopedia". The first volume was published in 1947 and the production schedule of six to seven months per volume has been closely maintained.

The original purpose of this encyclopædia, namely, to publish "a comprehensive treatment of the American Chemical Industry", has been more than accomplished, for the words "Chemical Technology" which define its scope have been taken to include a wide range of subjects including unit processes of chemical engineering, analytical methods, economic information as well as chemical and physical properties of many substances and industrial products.

This volume opens with an article on waxes of animal, vegetable and mineral origin. A vegetable wax such as carnauba, or an insect wax such as bees-wax, has a great variety of uses in many different industries, but from the section on economic aspects, their total production is small compared with that of the mineral waxes. The article states that medieval sealing wax was a wax, for it contained bees-wax. Modern sealing 'wax' is chiefly shellac and venice turpentine and not therefore a true wax. The article on wine reminds the European reader that this encyclopædia is essentially American. The output of French wines is about fifteen times as great as that of California, but the consumption in the United States is predominantly Californian wine, so there is good reason for the article being concerned particularly with wine production in California. The article, however, is well balanced and refers to methods of production of wine in many different countries.

A number of important products fall within the scope of the letter 'W', including wine, wood, wool. The articles on both the latter are comprehensive. Under 'X', perhaps there are still unknown technologies, but the articles dealing with xanthene dyes, X-ray analysis and xylenes show that there is much that is known under the letter 'X'.

There is only one main article under 'Y', but that is a particularly up-to-date and useful one for reference purposes, mentioning work by Winge, by Lindegren and others on the genetics of yeast, etc. There are a number of other references under letter 'Y', which appear in other articles in the encyclopædia; for example, an account of yttrium is to be found in the article on the rare-earth metals. The clear referencing to other articles is a feature of the encyclopædia.

The last letter of the alphabet is responsible for articles on zein, zinc and zirconium. In the wet milling of corn, the germ, fibre and starch are separated from the ground steeped grain, leaving the gluten of the endosperm. This gluten is about 70 per cent zein, which is the alcohol-soluble protein. It is used as zein fibre in the textile industry, for paper coatings, etc. The articles on zinc, zinc alloys, and zinc compounds occupy fifty-six pages, which contain much useful reference material; for example, curves are given summarizing work at the Bureau of Mines on the thermodynamics of the reduction process. Reduction and purification of zinc-bearing materials can be accomplished in a single step to a greater extent than for most metals because it possesses a relatively low boiling-point. The isolation of zirconium, on the other hand, owing to its high melting point (1,830° C.), its avidity for atmospheric gases and reactivity with most refractories offers great difficulties. The article on zirconium states that the estimated production in the United States, primarily for naval atomic power installations, was 168 tons in 1954. Under zirconium compounds, the hydride takes a prominent place, being employed as a 'getter' in the electronics industry.

'Zymosterol' ends this very comprehensive encyclopædia, from which clear information is quickly obtained about almost any subject which is within the field of, or relates to, chemical technology. Zymosterol does not, however, end the volume, which carries on from p. 313 for a further 623 pages of subject-index, serving the whole fifteen volumes. It is a detailed index of 50,000 entries and will be a most useful addition to the whole set of volumes: for example, there are 48 references to various volumes and pages under 'detergents', only nine of which are in the special article on detergents. Thus, the index greatly extends the usefulness of the encyclopædia for reference purposes.

This encyclopædia is a fine achievement. It is costly, but the trouble which has been taken to present the information clearly is worth much. It should become available in any library designed to meet the need of technologists. There are nearly 14,000 pages of text and 800 special articles.

The information is particularly valuable in summarizing the state of chemical technology in the United States at the present time; the economic and other information relating to the different products is well presented. An encyclopædia, like a butterfly, however beautiful, is ephemeral. It is, therefore, satisfactory to note that there is to be rejuvenation. A supplement volume is in preparation, which will include subjects in which there have been developments of exceptional interest since the original articles appeared, bringing them up to date. It is expected that this supplement will be available at the end of this year.

Alfred Egerton

BERTRAND RUSSELL'S CONTRIBUTION

Logic and Knowledge

Essays 1901–1950. By Bertrand Russell. Edited by Prof. Robert Charles Marsh. Pp. xi+382. (London: George Allen and Unwin, Ltd., 1956.) 25*s*. net.

THIS volume may be recommended to those unacquainted with the leading ideas of our greatest living philosopher. The selection of essays is based both on their intrinsic importance and on their inaccessibility. There is a consequent bias to the first quarter of the century, which, however, comprises that part of his thinking which is most original and most likely to be enduring; not much is included of his philosophical speculations provoked by the modern developments of physics.

Lord Russell played a leading part on his own, and in due course in conjunction with Whitehead, in elaborating a system of formal logic from which "all pure mathematics can be deduced without any new undefined idea or unproved propositions" (p. 325). This deduction is surely a matter of stupendous significance in relation to the nature of human knowledge and of mathematical knowledge in particular. Yet, oddly enough, Russell has not devoted as much attention as one would expect to elucidating that significance; and no successor has appeared of sufficient philosophical calibre to do that work for him. His own interests took a different turn.

The system involves the construction of what may be called a new logical language. In recommending this, together with the 'theory of types' which it incorporates and which was Russell's most important single contribution, he lays much stress on its power to rescue us from those embarrassments which are caused in our ordinary language by the unsatisfactory status of such statements as "the present King of France is bald", and by the contradictions involved in such statements as "I always tell lies". *Prima facie* these embarrassments strike one as essentially trivial, and, although the escape from them by a

new system of symbols is satisfactory enough, this motive for devising one scarcely seems worthy by itself of the heroic labours of the "Principia Mathematica".

There are, however, analogous contradictions in the sphere of mathematics, for example, in relation to trans-finite ordinals. "The ordinary mathematician is liable to fall into them when he approaches the realms of logic, unless he is very cautious" (p. 259). These contradictions are precluded by the new symbolism. A non-mathematician cannot judge whether their resolution is important in relation to the central themes of mathematics or, like that of "the bald King of France", rather on the periphery.

But Lord Russell's principal interest is different. The recurrent theme in much of his writing is that the new symbolic scheme serves to resolve, or expose as bogus, many of the central problems of traditional philosophy, notably those concerned with the 'real' existence of certain entities. Here the distinction between propositions and propositional functions is all-important, as is also that between a proper name and a description; the latter is used in, but is not a constituent of, propositions. For all his being a mathematician, of scientific temper, deeply versed in the developments of modern physics, and quite sceptical or even caustic about the power of philosophy to advance knowledge, he has continued to be attracted like a moth to the candle of metaphysics. He seems to value his new logic mainly because it gives him new arms with which to take his stand in the time-honoured metaphysical lists. Even there his work is not wholly destructive; he retains some urge, conscious though he is of all the pitfalls exposed by his own logical apparatus and of the ever-changing data thrown up by modern science, to construct some kind of system of his own. But in this he preserves the utmost tentativeness, and one should say, in relation to a man who has established so great a position for himself in the philosophical world, a notable modesty.

While it is not clear that Russell has made important contributions likely to be enduring outside the ambit of his logical system and its implications, he handles many conventional philosophical topics with as good a competence as anyone in our age, and is always fresh, lucid, penetrating and conscious of limitations. He has a rough, virile style, which seeks to give understanding without the use of great precision of language—precision is reserved for utterances in the new symbolic dress. He is always interesting, always intensely alive. One of the most readable popular accounts of his specific contributions is contained in his series of lectures on "Logical Atomism" (1918); the editor finds it "strange" that "they have never been reprinted in an authorized form"; it may not seem to others altogether strange, for while some of the lectures are most carefully worded expositions, others strike one as ill-prepared and even in places likely to have been *ex tempore* utterances. They are good none the less. (The editor does not give enough information about the provenance of his texts, and the lack of an index is a grave defect.)

The book is of interest, too, in relation to the state of modern philosophy. One has the impression that the fruits to be garnered from linguistic reconstruction and further linguistic analysis are likely to be limited in extent. Russell himself has exhibited many of them; his brilliant pupil, L. Wittgenstein, to whom he makes more than one expression of indebtedness, carried the matter further in his own whimsical way, and so have some other able successors. But there is a danger that, if we tarry too long in linguistic analysis, we shall remain enmeshed in trivialities of the "bald King of France" type. A passage (p. 185) from the lectures of 1918 should be cited:

"There is a good deal of importance to philosophy in the theory of symbolism. . . . I think the importance is almost entirely negative, i.e., the importance lies in the fact that unless you are fairly aware of the relation of the symbol to what it symbolizes, you will find yourself attributing to the thing properties that only belong to the symbol. That, of course, is especially likely in very abstract studies such as philosophical logic, because the subject matter that you are supposed to be thinking of is so exceedingly difficult and elusive that any person who has ever tried to think about it knows that you do not think about it except perhaps once in six months for half a minute. The rest of the time you think about the symbols, because they are tangible, and the thing you are supposed to be thinking about is fearfully difficult and one does not often manage to think about it. The really good philosopher is the one who does once in six months think about it for a minute. Bad philosophers never do".

R. F. Harrod

BIOLOGICAL DATA

Handbook of Biological Data

Edited by William S. Spector. Pp. xxxvi+584. (Philadelphia and London: W. B. Saunders Company, 1956.) 52*s.* 6*d.*

THE compilation of a handbook of biological data is an enormous task made more difficult by the diversity of organisms and functions which must be considered. The present volume, edited by William S. Spector, was compiled by 4,041 contributors who provided data which have been compressed into 448 tables with explanatory notes and some diagrams. The range of the volume is indicated by the sectional headings, which are: (1) biochemical and biophysical characteristics, (2) genetics, cytogenetics and reproduction, (3) development and morphology, (4) nutrition, ingestion and metabolism, (5) respiration and circulation, (6) other physiological activities and performances, (7) biologically active compounds, (8) environment and survival, (9) symbiosis and parasitism, and (10) ecology and biogeography. Each section is subdivided into many parts; for example, that on development and morphology includes size and growth-rate of trees, body- and organ-weights of vertebrates, life span of trees, animals, and pollen, and comparative anatomy of the heart.

A major difficulty had to be faced by the editor, namely, the variability of biological material. In a similar handbook of chemical data it is possible to give a list of, say, melting points which is exact, but this accuracy vanishes if one is making a table of capillary blood pressure, for this may vary with the individual. The solution presented in the volume under review is to state the mean value followed by the range within which 95 per cent of the records fall. Some of the data may therefore be inaccurate, as in some cases the assumption is made that the distribution is normal whereas it may in fact be skewed.

Nevertheless, the book is a very valuable one, giving, as it does, a range of information which would be quite impossible to find without a great deal of reading of scattered research journals. I have already found the volume of considerable value as a source of information to illustrate lectures on a variety of topics. Within a period of two weeks, use has been made of the tables on the nutritional requirements of lower Algae, the physical and chemical characteristics of antibiotics, and the expectation of life in various countries.

Two criticisms are valid, however, since they affect the utilization of the book. First, the tables are very complex with a large number of qualifying or descriptive footnotes, and can only be interpreted with careful study and much thought. Secondly, the value of a handbook of this type is directly proportional to the fulness and accuracy of the table of contents and index. For the purposes of this review, I tried to find the frequency of blood groups in the population of the United Kingdom or the United States. There is no entry in the index under either of the countries nor is there one under "Groups" or "Blood Groups", and under "Blood" there are thirty-three page references. The data were eventually found in a table headed "Blood Groups and Factors" in the section on genetics, cytogenetics and reproduction.

In the index, one finds under "Pine(s)", twenty-eight references, and under "Pinus spp.", twenty-seven references, but when these are compared, there are only nineteen in common. One would have thought that the similarity between "Pinus spp." and "Pine(s)" was sufficiently great not to justify this amount of discrimination.

With all its drawbacks, this volume is a bold effort to produce a handbook of use to all scientists working with living material. It is no fault of the editor or the contributors that the material is difficult to get into tabular form, and as a source-book of raw data it is indeed welcome. It is to be hoped that future editions can be more fully indexed or that the subsectional headings may be put in alphabetical or at least non-random order. Personal prejudice makes me object to a book weighing 4 lb. and measuring 9 in. × 11 in. being called a "Handbook".

A. R. Gemmell

GEOPHYSICS AND GEOCHEMISTRY

Physics and Chemistry of the Earth

Edited by L. H. Ahrens, Prof. Kalervo Rankama and S. K. Runcorn. Vol. 1. (Progress Series.) Pp. viii + 317. (London: Pergamon Press, Ltd., 1956.) 55*s*.

THE study of the Earth draws its methods from nearly all branches of science. There is therefore, as the editors of this collection say in their preface, a special need for critical reviews of many of the diverse topics that make up the Earth sciences. In this field everyone is, in a large degree, an amateur; no one knows enough to consider the great problems of geology as they really are and in the light of all the relevant information. Everyone needs a guide, such as these articles give, through the interpenetrating mazes of physics, chemistry, mineralogy and astronomy.

The book is the first of an annual series. It contains eight articles; the first, by Sir Harold Spencer Jones, discusses the origin of the solar system. The various catastrophic and accretion theories are reviewed with the conclusion that "the problem of formulating a satisfactory theory of the solar system is still not solved". The great difficulty is to devise a course of events that will lead to nearly all the mass being in the Sun and nearly all the angular momentum in the orbital motion of the planets. Alfvén has suggested that this is a magneto-hydrodynamic effect, but some of the assumptions needed to produce the result are far from plausible.

The second article is by J. Verhoogen and discusses temperatures within the Earth. Verhoogen emphasizes the undesirability of calculating these by applying the theory of thermal conduction to an assumed initial state, since this introduces the uncertainties surrounding the origin and early history of the Earth. Alternative estimates depending on the melting point of an iron core and on the electrical conductivity within the Earth are to be preferred. He concludes that a temperature of 3,000° K. at the core boundary is likely. This seems to me near the lower limit of possibly acceptable solutions.

L. H. Ahrens reviews determinations of the ages of rocks by the uranium–lead, potassium–argon and rubidium–strontium methods. The causes of discrepancies between the ages depending on the use of different combinations of lead and uranium ages are discussed. It is concluded that these are mainly due to loss of lead. An article on "Seismology and the Broad Structure of the Earth's Interior" by K. E. Bullen brings together the work that he, Jeffreys, Gutenberg and others have done on the distribution of elasticity and density within the Earth.

A long article by R. Hide discusses the hydrodynamics of the Earth's core; in the main this is directed to the explanation of the Earth's magnetic field. The problem is one of exceptional difficulty since, in addition to the inaccessibility of the core and the uncertainties about its constitution, temperature and electrical properties, there are the great mathematical difficulties of magneto-hydrodynamics. The diverse lines of evidence by which the relevant quantities can be estimated are well summarized. The dynamo and thermo-electric theories of the Earth's field are described, the author showing, on the whole, a preference for the former.

In the sixth article, R. Roy and O. F. Tuttle discuss investigations under hydrothermal conditions. It has long been known that the presence of water and other volatile constituents greatly modifies the behaviour of silicates at high temperatures. It is therefore very desirable that experiments should be made in the presence of water. It is only in the past few years that methods have been developed for applying high pressures and high temperatures simultaneously to such systems. The results are of great importance for an understanding of the processes occurring in the formation of rocks and of ore bodies. This review of a rapidly developing and complicated subject is most welcome.

The seventh article is a review by C. W. Correns of the geochemistry of the halogens. The editors state that such reviews of a group of elements will be a regular feature of these volumes. This article is largely a recital of facts, and is perhaps less readable than most of the rest of the book. The last article is a review of recent work on geochemistry in the U.S.S.R., containing an extensive bibliography.

Most of the subjects chosen for this book are developing rapidly and all are worth reviewing; the whole collection should stimulate interest in the physics and chemistry of the Earth.

E. C. Bullard

The Birds of the London Area since 1900

By a Committee of the London Natural History Society. (New Naturalist Special Volume.) Pp. x+305+24 plates. (London: William Collins, Sons and Co., Ltd., 1957.) 30*s*. net.

WITHIN a radius of twenty miles from St. Paul's Cathedral lies an area covered by the London Natural History Society. For many years bird-watching in this area has been organized and carried out by the Society, and the present book presents a report covering the half-century since 1900. This is really a remarkable book not only from the ornithological point of view but also as a history of organized study carried out by very many individuals, professional and amateur. The number of species of birds recorded in the area amounts to 245; in Inner London alone 160 species have been recorded and 37 have bred. The systematic list, which takes up two-thirds of the book, is an extraordinarily detailed and historically fully documented local avifauna. It is apparent that of all the large cities of the world London is the first to possess such a long and well worked out ornithological history.

Of more general interest are the chapters devoted to the different ecological environments which can be distinguished within the area. Twelve contributors write on different urban and suburban biotops, separate chapters being devoted to physical setting, migration, and roost and fly lines. These chapters are of great general interest as special emphasis has been laid on changes which have occurred during the past fifty years and their influence on bird life in the urban and suburban areas. The influences and results of two wars, the disappearance of horses, the extension of water reservoirs and many other changes have been discussed in detail, giving an interesting picture of the development of bird life in the greatest urban conglomerate of the world. For the Londoner interested in birds the book is a true encyclopædia and an indispensable source of reference, and for ornithologists everywhere it is a very interesting study of urban bird life during the past half-century.

W. RYDZEWSKI

Colour Television Fundamentals

By Milton S. Kiver. (McGraw-Hill Television Series.) Pp. vii+312. (London: McGraw-Hill Publishing Company, Ltd., 1955.) 32*s*. 6*d*.

THE growing number of colour television receivers in the United States has posed many new problems of receiver maintenance, and it is not surprising to find that an attempt has been made to provide a manual by which the maintenance technician may acquaint himself with the new techniques. Such is the purpose of the book under review. The text commences with an explanation of the National Television System Committee colour television system, which is probably adequate for the purely practically minded reader, but the contents are concerned primarily with current colour television receiver design, on the assumption that the reader is very familiar with black-and-white practice.

The general form of the colour receiver is discussed in detail and information is given concerning particular circuit arrangements favoured by different manufacturers. A very useful description of the three-gun colour tube and its associated circuits includes detailed instructions for adjusting tube registration, an essential requirement for good pictures. A succeeding section describes general methods for alignment and maintenance, and procedures are outlined by their application to two domestic receivers having significant design differences; the main text is concluded by some guidance to the service technician in diagnosing the causes of incorrect receiver operation. Finally, the two appendixes respectively add information about the system laid down by the National Television System Committee in addition to that given early in the book and show the formal text of the signal specification.

The presentation is quite good, the diagrams are both clear and helpful, and the style of writing, being very informal, helps to maintain the reader's interest. The book should be of value mainly to those readers engaged in either the production testing of receivers or their home maintenance. As colour television in Britain is still in the experimental stage, the immediate demand for this book in Britain will probably be somewhat limited.

A. V. LORD

Ciba Foundation Symposium on Paper Electrophoresis

Edited by G. E. W. Wolstenholme and Elaine C. P. Millar. Pp. xii+224. (London: J. and A. Churchill, Ltd., 1956.) 35*s*. net.

THOUGH very widely used, paper electrophoresis is not a standardized technique. There are many variations in the types of apparatus and conditions are often chosen empirically. Consequently, it is extremely valuable, for a clearer understanding of the many factors involved, for the Ciba Foundation to have brought together a number of experts and to have recorded their discussions. In common with other Ciba symposia, a number of papers are presented, followed by discussion. Because of the small number of people present, the discussions are informal and uninhibited. The topics cover a wide field and deal fully with physiochemical principles, apparatus and applications. An important feature is the bringing together of much data on the measurement of serum proteins, including glyco- and lipo-proteins, of interest in the clinical field, and there is considerable discussion on the methods of evaluating these constituents. Altogether, the book makes interesting and instructive reading. An index of authors of the many publications cited in the text would have enhanced the book's value; nevertheless, it is a very useful contribution to the subject of paper electrophoresis and should be in the hands of all who use this technique.

R. CONSDEN

Organo-Metallic Compounds

By Prof. G. E. Coates. (Methuen's Monographs on Chemical Subjects.) Pp. viii+197. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1956.) 12*s*. 6*d*. net.

UNTIL fairly recently, the term organometallic compounds has usually implied the Grignard magnesium derivatives to most organic chemists. Over the past ten years, however, an impressive array of organic derivatives of other metals and metalloids has been added to the armoury of organic chemistry, and the subject represents a fruitful meeting-place of the organic and inorganic disciplines. This little book gives a most useful bird's-eye view of the whole field. Although not devised as a practical text-book, enough details of reactions and conditions are given to stimulate many ideas for the use of these reagents. Well documented with key references, this monograph is well worth its low price.

R. A. RAPHAEL

SYNTHESIS OF CELL CONSTITUENTS FROM C_2-UNITS BY A MODIFIED TRICARBOXYLIC ACID CYCLE

By Dr. H. L. KORNBERG and Prof. H. A. KREBS, F.R.S.

Medical Research Council Cell Metabolism Research Unit, Department of Biochemistry, University of Oxford

MAJOR advances have recently been made towards the closure of one of the outstanding gaps in the knowledge of intermediary metabolism. This gap concerns the metabolic processes by which two-carbon compounds, such as acetate or ethanol, can be converted to cell constituents in those organisms which can meet all their carbon requirements from these compounds. Bacteria of the genus *Pseudomonas*, many strains of *Escherichia coli* and many moulds belong to this group. The occurrence of a cyclic process, representing a modification of the tricarboxylic acid cycle, has been newly established in these organisms.

Experiments on Acetate-grown Cells of *Pseudomonas*

To find the first, or an early, metabolic product of acetate, acetate labelled with carbon-14 was added to cells of *Pseudomonas KB* 1[1] growing on ammonium acetate as sole carbon source, and the radioactive compounds formed after very short periods of incubation were located by autoradiography and analysed[2]. In the hands of Calvin and his collaborators, this procedure had led to the identification of phosphoglyceric acid as the first organic compound containing fixed carbon dioxide in photosynthesizing cells[3]. However, analogous experiments with acetate on whole cells of *Pseudomonas*[2,4] remained inconclusive. This organism oxidizes acetate by the reactions of the tricarboxylic acid cycle[1,5], and the intermediates of this cycle therefore became rapidly labelled. Even after only 3 sec., citrate, malate, fumarate and succinate, and some amino-acids directly derived from the cycle (glutamate and aspartate), contained radioactive carbon. It did not prove possible in these experiments to limit the radioactivity to virtually one compound, as in the case of photosynthesis. The distribution of the radioactivity among the labelled compounds formed from labelled acetate, and the change of labelling with time, suggested that acetate entered the tricarboxylic acid cycle at two points, to form citrate at one and a C_4-dicarboxylic acid at another[2]. Subsequent work on extracts[5,6] confirmed this conclusion.

Malate Synthetase

A decisive step was the observation made on extracts of *Pseudomonas* that the removal of acetate can be promoted in two ways. The first, established in 1951 by Ochoa, Stern and Schneider[7], consists of the addition of oxaloacetate, in the presence of coenzyme *A* and adenosine triphosphate. The reactions occurring under these conditions are the well-established stages of the tricarboxylic acid cycle leading to citrate:

Acetate + coenzyme *A* + ATP → acetyl coenzyme *A* (+ AMP + PP)*

Acetyl coenzyme *A* + oxaloacetate → citrate (+ coenzyme *A*)*

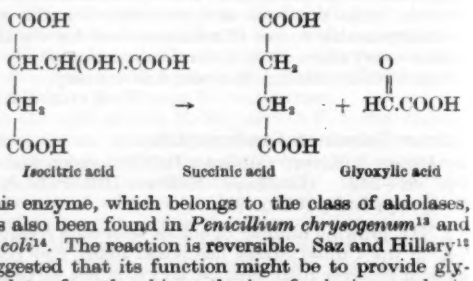
The second way of promoting acetate utilization consists of the addition of glyoxylate, in the presence of coenzyme *A* and adenosine triphosphate. The metabolic process responsible for this removal of acetate proved to be identical with the malate synthetase reaction discovered by Wong and Ajl[8] in extracts of *E. coli*:

Acetate + coenzyme *A* + ATP + glyoxylate → malate (+ coenzyme *A* + AMP + PP)*

The action of malate synthetase is closely analogous to that of the citrate-forming condensing enzyme[7]. In both cases, the methyl group of acetyl coenzyme *A* condenses with a —CO.COOH grouping.

Isocitritase

Pseudomonas was already known to possess an enzyme which can supply glyoxylate. This is the '*iso*citritase' which splits *iso*citrate to glyoxylate and succinate[9–12]:



This enzyme, which belongs to the class of aldolases, has also been found in *Penicillium chrysogenum*[13] and *E. coli*[14]. The reaction is reversible. Saz and Hillary[12] suggested that its function might be to provide glyoxylate for the biosynthesis of glycine and, in reverse, to provide a cyclic mechanism for the oxidation of compounds more highly oxidized than acetate, such as glycine and glycollate. It has also been suggested[14] that the glyoxylate may be oxidized to carbon dioxide and water, possibly via formate, and that this therefore represents an alternative mechanism for the complete oxidation of acetate.

The 'Glyoxylate Bypass'

The following results[5,6] show that the glyoxylate, formed by the action of *iso*citritase, can react with acetyl coenzyme *A* to form malate:

(*a*) Cell-free extracts of *Pseudomonas*, in the presence of glutathione, adenosine triphosphate and coenzyme *A*, catalyse the condensation of labelled

* These compounds (in brackets) have not been identified in the present work, but are presumed to arise, by analogy with previous work.

acetate and glyoxylate to form malate as the only labelled compound.

(*b*) When *iso*citrate is used instead of glyoxylate in the above system, malate is again the only labelled compound formed in short-term experiments.

(*c*) Incubation of extracts with *iso*citrate leads to the production of equal amounts of glyoxylate and succinate. In the presence of acetate, coenzyme *A* and adenosine triphosphate, the glyoxylate disappears and malate is formed. The amounts of *iso*citrate utilized are approximately equal to the amount of succinate, and the amounts of malate + glyoxylate, formed.

(*d*) No malate is formed when boiled cell extracts are used for the above experiments, nor when acetate, coenzyme *A* or adenosine triphosphate is omitted.

It is evident that the combined action of *iso*citritase and malate synthetase can replace the steps of the tricarboxylic acid cycle leading from *iso*citrate to malate. In the tricarboxylic acid cycle, these steps are oxidative:

$$Isocitrate + 1\tfrac{1}{2}\ O_2 \rightarrow malate + 2\ CO_2$$

whereas the combined action of *iso*citritase and malate synthetase is an anaerobic process:

$$Isocitrate + acetate \rightarrow succinate + malate$$

The existence of this 'glyoxylate bypass'[8] implies that there are two variants of the tricarboxylic acid cycle in *Pseudomonas*. One is the well-established terminal pathway of acetate oxidation (Fig. 1). The effect of one turn of this cycle is the complete oxidation of acetate:

$$CH_3COOH + 2\ O_2 \rightarrow 2\ CO_2 + 2\ H_2O$$

The second variant employs most of the reactions of the tricarboxylic acid cycle but substitutes the 'glyoxylate bypass' for the degradative reactions between *iso*citrate and malate. The net effect of one turn of this cycle, henceforth referred to as the 'glyoxylate cycle' (Fig. 2), is the synthesis of one molecule of succinate from two molecules of acetate:

$$2\ CH_3COOH + \tfrac{1}{2}\ O_2 \rightarrow HOOC.CH_2.CH_2.COOH + H_2O$$

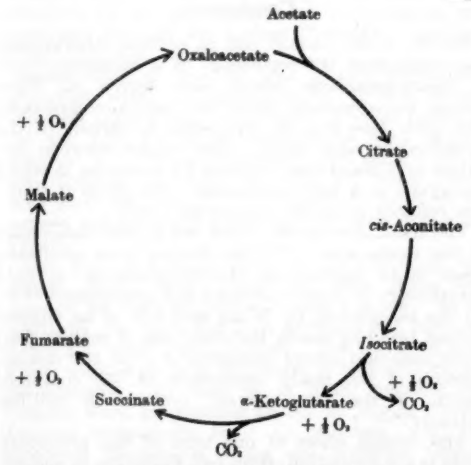


Fig. 1. The main stages of the tricarboxylic acid cycle

Acetate reacts in the form of acetyl coenzyme *A*. The net effect of one turn is: acetate + 2 O_2 → 2 CO_2

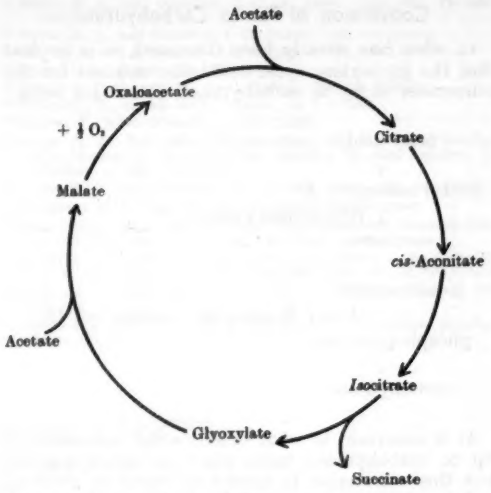


Fig. 2. The main stages of the 'glyoxylate cycle', which is a variant of the tricarboxylic acid cycle

Acetate reacts in the form of acetyl coenzyme *A*. The net effect of one turn of the cycle is 2 acetate + $\frac{1}{2}O_2$ → succinate. If the succinate formed is further metabolized, the cycle, together with the subsequent reactions of succinate, can lead to the synthesis of other metabolites

The occurrence of a reaction leading from two molecules of acetate to one molecule of succinate was first postulated by Thunberg[15] in 1920, and later by Knoop[16]. These authors assumed a rather direct condensation of two molecules of acetate ("Thunberg condensation"); but it is now apparent that the same effect can be achieved by an entirely different mechanism, involving as intermediate stages the reactions of the glyoxylate cycle:

Acetate + oxaloacetate	→ citrate
Citrate	→ *iso*citrate
*Iso*citrate	→ succinate + glyoxylate
Acetate + glyoxylate	→ malate
Malate + $\frac{1}{2}\ O_2$	→ oxaloacetate
Sum: 2 acetate + $\frac{1}{2}\ O_2$	→ succinate.

Biological Role of the Glyoxylate Cycle

The glyoxylate cycle accounts for the net synthesis of C_4-dicarboxylic acids from acetate when this is the sole source of carbon, and it therefore provides the oxaloacetate required for the continued operation of the tricarboxylic acid cycle. It is also a key step in the synthesis of many cell constituents. Extracts of *Pseudomonas*, in the presence of pyridine nucleotides, can convert malate to phosphopyruvate, which can yield hexoses by the reversal of the reactions of glycolysis[17,18]. Hexoses in turn can supply pentoses through the pentose phosphate cycle, as well as the carbon skeletons of several amino-acids. The intermediates of the tricarboxylic acid cycle together with acetyl coenzyme *A* are already known to supply the carbon skeletons of most amino-acids. Such intermediates, drained from the tricarboxylic acid cycle, can be readily regenerated from acetate by the glyoxylate cycle.

Conversion of Fat to Carbohydrate

In what has already been discussed, it is implied that the glyoxylate cycle could also account for the conversion of fat to carbohydrate, the stages being:

fatty acid
↓
acetyl coenzyme *A*
↓ (glyoxylate cycle)
succinate
↓
oxaloacetate
↓ (Utter–Kurahashi reaction, ref. 18)
phosphopyruvate
↓
carbohydrate

It is uncertain to what extent a net conversion of fat to carbohydrate takes place in higher animals, but this conversion is known to occur in seedlings rich in oil, such as those of the castor bean (*Ricinus*). Cell-free extracts of castor bean seedlings contain *iso*citritase and malate synthetase, and are able to catalyse the formation of malate from acetate and *iso*citrate via the glyoxylate bypass[15]. In conjunction with the reactions whereby fatty acids give rise to acetyl coenzyme *A*, and those whereby malate produces phosphopyruvate[16], the bypass thus provides a route for the net conversion of fat to carbohydrate.

Tissues of higher animals are known to be capable of incorporating labelled acetate (and therefore the carbons of fatty acids) into carbohydrates; but this does not imply a net conversion of fat to carbohydrate. When labelled acetate enters the tricarboxylic acid cycle, the citrate formed is labelled in such a manner as to lead, on completion of one turn of the cycle, to the formation of C_4-dicarboxylic acids still retaining all the isotope of the added acetate: the two molecules of carbon dioxide evolved are not directly derived from the added acetate. Hence, although the entry of two carbon atoms (as acetate) has been followed by the liberation of two carbon atoms (as carbon dioxide), and no net synthesis has occurred, the C_4-dicarboxylic acids of the tricarboxylic acid cycle have nevertheless become labelled. Since these acids can readily give rise to phosphopyruvate[17], isotope will also appear in carbohydrates, but will not be accompanied by any net formation of carbohydrate. The glyoxylate cycle, by supplying extra C_4-dicarboxylic acids from acetate, could, however, account for a net synthesis of carbohydrate from acetate and hence from fat. It remains to be investigated whether higher animals can under special conditions—such as when fat is the main source of energy—convert fat into carbohydrate, and whether this involves the glyoxylate cycle.

Synthesis of Citric and Fumaric Acid in Moulds

The conversion of sugars to citric acid by *Aspergillus niger* is taken to involve a fission of C_6-sugars to triose phosphates, oxidation to pyruvate, the fixation of carbon dioxide to form oxaloacetate, and a condensation of this with a molecule of acetyl coenzyme *A* derived from another molecule of pyruvate (see Chain[20]).

This pathway cannot account for the synthesis of citric acid from acetate or from other two-carbon compounds. The occurrence of *iso*citritase in at least one mould[13] suggests that the accumulation of citric acid involves the glyoxylate cycle, the intermediate stages being:

Acetate + *iso*citrate	→ succinate + malate
Malate + $\frac{1}{2}$ O_2	→ oxaloacetate
Succinate + O_2	→ oxaloacetate
2 Acetate + 2 oxaloacetate	→ 2 citrate
Citrate	→ *iso*citrate
Sum: 3 Acetate + $1\frac{1}{2}$ O_2	→ citrate

Citrate, besides being the end-product of acetate utilization under these conditions, also acts in the manner of a catalyst, in that it initiates the sequence of reactions and is regenerated by them.

Foster and his co-workers[21,22] concluded from isotopic data that the synthesis of fumaric acid from acetate or ethanol in the mould *Rhizopus nigricans* involved a 'dicarboxylic acid cycle', in which the two methyl groups of acetate or ethanol, via the Thunberg condensation, give rise to the two methylene carbons of the C_4-compound. The experimental results are, however, in even better agreement with the assumption that fumarate is formed by the reactions of the glyoxylate cycle, the steps being:

*Iso*citrate	→ succinate + glyoxylate
Acetate + glyoxylate	→ malate
Malate + $\frac{1}{2}$ O_2	→ oxaloacetate
Acetate + oxaloacetate	→ citrate
Citrate	→ *iso*citrate
Succinate + $\frac{1}{2}$ O_2	→ fumarate
Sum: 2 Acetate + O_2	→ fumarate

The accumulation of fumarate in this organism could be ascribed to the absence or low activity of fumarase. As in the case of the citric acid-forming moulds, citrate and *iso*citrate act like catalysts.

Conclusion

Recent work, carried out in several laboratories, has established the occurrence of a metabolic cycle in micro-organisms which can derive all their carbon requirements from two-carbon compounds. The cycle (see Fig. 2) represents a variant of the tricarboxylic acid cycle. The stages between *iso*citrate and malate are replaced by reactions in which glyoxylate is a key metabolite. The cycle is therefore referred to as the 'glyoxylate cycle'.

The main discoveries which led to the elaboration of the cycle were: (1) the finding that *iso*citrate, apart from undergoing dehydrogenation, is split enzymically to form succinate and glyoxylate[9–14,23]; (2) the recognition by Wong and Ajl[9] of an enzyme system bringing about the synthesis of malate from glyoxylate and acetyl coenzyme *A*; (3) the demonstration of the ready occurrence of the combined action of the two enzyme systems in cell-free extracts[5,6,15].

The overall effect of one turn of the glyoxylate cycle is the formation, from two molecules of acetate, of one molecule of C_4-dicarboxylic acid. This, together with acetate, can serve as a precursor of many cell constituents. The cycle is therefore a stage in the

synthesis of cell material from acetate. It can also account for the net formation from acetate of citric, fumaric and other organic acids in moulds[10].

The key reactions of the glyoxylate cycle have further been demonstrated in *Ricinus* seedlings[19]. In these seedlings, it can account for the conversion of fat to carbohydrate.

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RADIOBIOLOGY AND CANCER

By Dr. L. H. GRAY

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THE opening of the British Empire Cancer Campaign Research Unit in Radiobiology by His Grace the Duke of Devonshire on May 20 marks a new phase in the research into the nature and treatment of cancer which the Cancer Campaign has supported at the Mount Vernon Hospital for more than twenty-five years. It is also an expression of the belief that the study of fundamental problems in radiobiology by a group of scientists can make a significant contribution to our understanding of cancer, if the group is consciously working to this end and is located at a hospital in close association with medical and scientific colleagues whose efforts are similarly directed. Experimental research interests at the Mount Vernon Hospital include the etiology of cancer, chemical carcinogenesis, chemotherapy and radiobiology. In close association with those conducting clinical research in radiotherapy, a group is studying the cytological changes induced in human tumours by a course of X-ray treatment. The activities of all the groups are co-ordinated and controlled through the Cancer Research Committee of the Hospital.

Radiobiological research was at first particularly concerned with the measurement of the relative biological effectiveness of different types of radiation, and the first biological experiments with neutron radiation to be made in Britain were carried out at this Hospital by Mottram and by Spear, using neutrons from a 380 kV. (D-D) generator built for this purpose some twenty years ago by Gray, Read and Wyatt[1].

The new Research Unit in Radiobiology was created nearly three years ago when plans were initiated for the programme outlined below. In the meantime, the Unit has been growing, and has been working in temporary quarters. The theme of most of this work is the role of oxygen in radiobiology and radiotherapy. In this, as in other respects, the research work in progress to-day at Mount Vernon Hospital owes much to J. C. Mottram, who was appointed pathologist when the Hospital became entirely devoted to cancer treatment and research in 1931. Mottram was a keen observer—indeed, he was a naturalist at heart—and carried out many experiments with the view of discovering the factors which influence the regression of an irradiated tumour. He observed that when the blood-flow in the tail of a mouse was stopped, either by compression or by ligature, radiation damage to the skin was much reduced. He also observed that the regression of a rat tumour, following a given dose of radiation, was much reduced when the rat was rendered anæmic by bleeding just before irradiation. These experiments have a very modern flavour, but it is interesting to note that this approach to the study of the influence of oxygen on the response of cells to radiation was in origin through an exploration of the role of the vascular tumour bed. It was only later, in the light of the experiments of Crabtree and Cramer[2], that Mottram studied the influence of anaerobiosis on the radiosensitivity of roots, and came to identify oxygen transport as a key function of the vascular bed. Read pursued this theme, and there resulted his classical experiments with Thoday[3,4], which established (1) that anaerobiosis may reduce the radiosensitivity of a tissue by a factor of 3, (2) the fact that oxygen has little influence on the damage induced by α-radiation, (3) the speed with which the radiosensitivity of a cell changes in response to changes in oxygen tension, and (4) the quantitative relationship which exists between the radiosensitivity of a tissue and the oxygen tension in its immediate environment.

Why is it that X-radiation is several times more damaging if oxygen is freely available to cells at the time of irradiation? Is the role of oxygen metabolic? Is oxygen unique, or can its place be taken by another molecule? Or again, why is it that structural damage to chromosomes, which is almost invariably dependent upon oxygen when induced by X-radiation, is independent of oxygen tension when induced by nitrogen mustard and many other of the so-called radiomimetic chemicals? One may also ask why the induction of chromosome structural damage by radiation is sensitive to oxygen, while the induction of some kinds of gene mutation, as well as the inactivation of pneumococcal 'Transforming Principle' which is practically pure deoxyribonucleic acid, is apparently not sensitive to oxygen. These are a few

of the many questions which cannot yet be fully answered.

That the role of oxygen is not entirely metabolic seems clear from several lines of observation. First, it is as great in cells the metabolism of which is brought to a low level by reduced temperature or by enzyme poisons as in actively respiring cells. Secondly, however short the irradiation, it is found that the oxygen needs to be present only during the actual period of exposure to radiation. Thirdly, a given type of injury sustained by a given cell is found to be sensitive to oxygen when that injury is initiated by X-rays, but not appreciably sensitive when initiated by alpha radiation. On the other hand, however, it is most improbable that oxygen plays no metabolic part at all. Indeed, there are strong indications that certain types of chromosome structural damage are influenced by a long period of anaerobiosis before or after irradiation[5,6]. Few radiomimetic chemicals are oxygen-sensitive in their action, but one (8-ethoxycaffeine), which is very closely radiomimetic when acting on aerobic plant cells, is almost without effect on the chromosomes of anaerobic cells. In this case the role of the oxygen appears to be essentially metabolic since oxygen is inactive in cells poisoned by cyanide or in which phosphorylation is uncoupled from oxidation by dinitrophenol[7]. Chromosome structural damage, which is microscopically indistinguishable from that produced by 8-ethoxycaffeine, is little, if at all, affected by cyanide or dinitrophenol when induced by ionizing radiation in the presence of oxygen.

It would appear that the dominant role of oxygen in the initiation of damage by ionizing radiation involves the participation of the oxygen molecule in the immediate chemical changes to which the irradiation gives rise. Inasmuch as many cellular lesions manifested by irradiated cells appear to be nuclear in origin, the oxygen has probably to be in the nucleus to be effective. In what concentration it must be present is not known. The recent work of Alper and Flanders[8] has shown that as little as 3·5 μM/litre (that is, equilibrium with gas containing 0·25 per cent oxygen) in the environment of a bacillus suffices to convey a marked increase in radiosensitivity relative to the completely anoxic cell. Concentrations not much greater than this suffice to confer increased sensitivity on mouse tumour cells (Deschner and Gray, in the press). The required concentration within the cell may be very much less than this, since Longmuir[9], from his studies of the influence of oxygen tension on the rate of utilization of oxygen by bacteria and by their extracted cytochrome oxidases, has inferred that in certain bacteria (for example, *B. megatherium*) the intracellular oxygen tension may be a hundred times smaller than that in the extracellular fluid.

In a mammal, the amount of oxygen available to cells composing a tissue may be reduced by procedures which interfere with any one of a number of steps, which include pulmonary exchange, blood flow through the capillaries, and transport from the capillaries across intervening metabolizing tissue. An important part of the action of some 'radioprotective' drugs is undoubtedly due to lower venous oxygen tension. These drugs have never been observed to confer upon mammals more protection than would correspond to a difference between aerobic and anaerobic cellular sensitivity, and their effect is offset if the animal breathes a gas enriched in oxygen at the time of irradiation[10]. While venous tension cannot fall below a certain critical level without causing the death of the animal, the further fall in tension between the capillaries and more distant cells may, even without external interference, reduce the tension to a very low level in certain situations. One such set of conditions is believed to exist in the growth of certain human tumours[11], thereby greatly increasing the difficulty of delivering an adequate dose to all parts of the tumour. These facts also provide a rationale for the administration of oxygen to patients before and during each X-ray treatment[12-14].

As a result of cellular respiration, the oxygen tension may vary markedly from point to point within plant and insect, as well as in mammalian tissues. It will, for example, be less on the axis of a root or at the centre of an anther than in the liquid or gaseous media surrounding these structures. It is probable that oxygen gradients through tissues greatly influence the observed relation between sensitivity and the oxygen tension in the environment of the tissue, and for this reason it is unfortunate that much of our information concerning the influence of oxygen on radiosensitivity comes from the study of tissues and not cell suspensions. Inert gases, under pressure, have recently been found by Ebert and Howard (*Rad. Res.*, in the press) to depress the radiosensitivity of roots exposed to X-rays in the presence of oxygen. The effect is shown by all the inert gases so far examined, which increase in effectiveness in the order nitrogen, argon, krypton, xenon. The extent of the depression in radiosensitivity depends on the inert gas, on the pressure at which it is applied, and on the partial pressure of oxygen in the mixture. It is known that these gases have an anæsthetic effect on mammals, and it is thought that the two phenomena may have some connexion. In general terms, it must be supposed that these gases prevent the expression of aerobic sensitivity by interfering either with the passage of oxygen through the cell (thereby also increasing oxygen gradients in a tissue) or by competing with oxygen for the occupation of some sites within the cell from which the oxygen would normally enter into those chemical changes which lead to cytological damage.

As the literature citations have shown, there is a large number of radiobiologists in Britain actively interested in these problems. For the small group in the Research Unit in Radiobiology at the Mount Vernon Hospital these problems are the focal point of most of their present activities, but they are seen as a particular aspect of the wider problem of understanding the nature of the chemical and metabolic steps which follow immediately upon exposure of a cell to ionizing radiation. Present indications are that the initial reactions are rapid, occupying times of the order of microseconds or less. In order to investigate these initial steps in the development of radiobiological damage, it is desirable to be able to deliver the whole dose in comparable times. In 1953, when the formation of this new Research Unit was contemplated, the research department of Messrs. Metropolitan-Vickers, under the direction of Dr. Willis Jackson, was asked to develop for the British Empire Cancer Campaign a high-current electron-pulse generator to meet this requirement.

The machine, which is about to be brought into commission, can deliver pulses of 1·5 MeV. electrons having a duration of 2 μsec. and a current in the pulse greater than 1/2 amp. On test, values up to

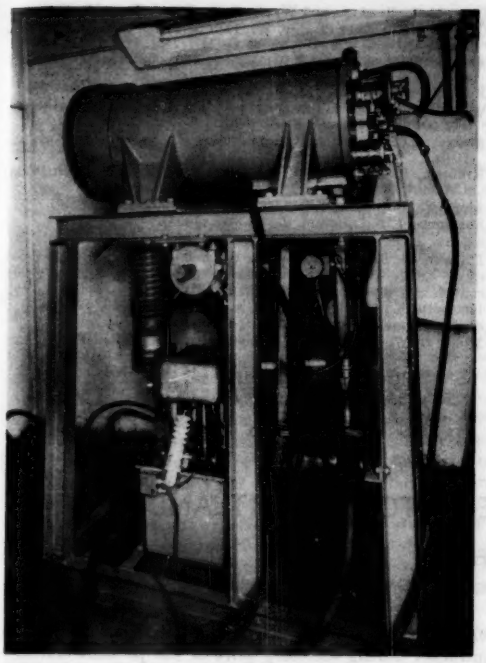

Fig. 1. 1·5 MeV. electron accelerator on test. The cylindrical vacuum tank containing the wave guide and focusing coils rests on a channel iron framework supporting the pumps, magnetron, pulse transformer and other components

3/4 amp. have been obtained. These pulses can be repeated at frequencies up to 350 pulses/sec. Provision is also being made for firing single pulses and pairs of pulses, the two pulses in a pair being spaced at any time interval from a few microseconds upwards.

The apparatus is constructed in the main from standard parts built by the Metropolitan-Vickers Co. for its 4 MeV. linear electron accelerators designed for clinical work[15,16]. The power unit is a standard 2 MW.–10 cm. magnetron, but the corrugated waveguide system and the electron gun are specially designed to produce and accelerate the highest possible beam current. Without auxiliary focusing the beam has a cross-section of about 1 cm.^{2} at exit from the machine, and hence a single pulse of electrons will deliver a dose of 10^6 rads to a volume of the order of 1 cm.^{3}. By providing two quadrupole focusing magnets close to the beam window, about 30 per cent of the current can be focused through a 2 mm. diameter hole, and in this case the dose per pulse close to the hole will be of the order of 10^6 rads to a volume of a few cubic millimetres. In order to obtain two pulses spaced only a few microseconds apart, an additional delay line has been added to the modulator. Both delay lines are charged by the usual charging circuit and they are discharged in succession through separate hydrogen thyratrons, the spacing of the pulses being determined by the setting of the thyratron triggering circuit.

Evidence of immediate changes in living cells will be sought by microscopic and spectroscopic examination, using the light flash proceeding from an underwater spark between uranium electrodes (Boag, in the press). In its present form, a flash suitable for spectroscopy lasts about 10 μsec., but this time may be shortened. Evidence for the production of radicals in cells, cell components and chemical systems will be sought by the techniques of microwave spectroscopy, particularly electron spin resonance. Ability to deliver the whole dose in about 2 μsec. will also make it possible to study the influence of changing the environment of the cell before damage has become irreversible.

The building comprises a single-storied radiation wing which provides for radiation studies with the electron pulse generator and with a conventional 200 kV. constant potential X-ray generator. The two-story section of the building contains laboratories for physics, chemistry and physiology, biochemistry, and general biology, a well-equipped workshop, offices, and a room which serves jointly as staff room, library and colloquium room. The accommodation was designed to meet the needs of a permanent staff of five, together with three visitors. In a subject which covers so many specialities, and in which the point of attack at any one time may involve the use of different biological materials and different techniques from those required at other times, it is particularly helpful to be able to invite the collaboration of visitors whose experience is complementary to that of the permanent staff.

While full financial responsibility for the running of the Unit rests with the British Empire Cancer Campaign, the Campaign is precluded by its policy from using its subscribed income for capital building costs. The establishment of the Unit has been made possible through much goodwill and generosity. An ideal site has been provided by the Hospital Management Committee close to the other experimental research buildings, but at the periphery of the occupied land, so that the X-ray and electron pulse generators direct their radiations through thick concrete walls out across sloping fields leased by the

Fig. 2. British Empire Cancer Campaign Research Unit in Radiobiology. The radiation sources are contained in the rooms with windows near the ceiling level

Hospital for grazing. All concerned are very greatly indebted to a generous donor, who chooses to remain anonymous, for the gift of £25,000 with which the laboratories were built and equipped. This figure does not, of course, include the cost of the electron pulse generator or of scientific apparatus. The total floor area is 5,500 sq. ft. The cost has been about ten shillings per cubic foot. This rather low rate for a building completed in October 1956 has only been achieved by a determined effort at strict economy in design and materials. That the building is both pleasing and functionally satisfactory, therefore, reflects great credit on the architects, Messrs. Waterhouse and Ripley.

It is hoped that these well-equipped laboratories will make possible investigation of some fundamental problems in radiobiology which have scarcely been examined hitherto for lack of radiation facilities.

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ROYAL GREENWICH OBSERVATORY, HARTLAND

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ALTHOUGH the directive properties of the magnetic compass have been known from very early times, quantitative determinations of the magnetic declination do not appear to have been made until about the sixteenth century. At this time, however, a number of such observations were obtained, mostly in Europe. In 1580 William Borough found that in London the compass needle pointed about eleven degrees east of north. Observations made in Paris about this time suggest that Borough's observation was obtained when the declination at London had attained its most easterly value.

With the foundation of the Academie des Sciences in Paris and the Royal Society of London during the following century, interest in these matters was greatly stimulated and there followed a long series of observations which provide a good indication of the changes that have taken place over the years. That such changes were in fact taking place was recognized by Henry Gellibrand in 1634 when the value of the declination at London had decreased to about 6° E.

It was Graham, the instrument and clock maker, who, also working in London, discovered in 1722 that the magnetic needle varied its direction throughout the day. Both Halley, the second Astronomer Royal, and his successor, Bradley, were interested in the variation of the compass, and it was the former who, about 1700, produced the first chart of magnetic variation, employing isogonic lines, devised by himself, to indicate the tracks over which the declination remained the same. This chart covered the Atlantic Ocean and was published as an aid to navigation.

That a magnetized needle mounted freely upon horizontal pivots will dip under the influence of the Earth's magnetic field had been shown by Georg Hartmann of Nuremberg as early as 1544, but it was not until much later that satisfactory observations of magnetic inclination were obtained. Not, in fact, until the application of the so-called earth, or dip, inductor during the early part of the present century, did it become possible to secure observations of inclination comparable in accuracy with those available of declination. Nevertheless, that the inclination was undergoing a steady change similar to that observable in declination had become known during the seventeenth century.

A further advance was made when in 1747 Hiorter at Upsala announced a connexion between large movements in the compass needle and the occurrence of auroræ. By the end of the century magnetic observatories were being devised. The *Philosophical Transactions* for 1796 include a paper by John Macdonald in which he describes his observatory at Fort Marlborough, Sumatra, where he secured a series of observations to determine the diurnal variation in declination. The observatory he describes as "a small building devoid of iron", and he says "to exclude every influence of iron, I laid aside such as might be about me, previous to taking the observations and took care to remove the padlock and key at the same time to a certain distance from the construction". The 'drill' remains unchanged to-day. In a second paper published in 1798 he says, "The sciences of electricity and magnetism (in my opinion intimately connected) are at present in their infancy. We observe effects which we cannot trace up to any satisfactory cause. If observations similar to this and to those made by Mr. Canton* could be made in equal latitudes and longitudes and in corresponding positions in the torrid zones, by collating the results, I think a rationale of this wonderful phenomenon might be obtained". By "collating the results" of just such a network of observations we have since his day arrived at our present understanding of a range of phenomena.

* Canton, working in London, found in 1759 that the diurnal variation in declination on magnetically quiet days was greater in summer than in winter.

To-day there are some hundred or more magnetic observatories distributed over the world. New ones appear from time to time, others disappear, but there remain several that have furnished magnetic data extending over the past century, though most of these, like Greenwich, have been compelled by building development to find new and more suitable sites to carry on their work. Of them all, Colaba–Alibag (transferred 1905) and Greenwich–Abinger (transferred 1925) appear to have the most comprehensive records, both having published extensive series of results in all the elements necessary to define the total field since 1846. It should be added, however, that the early observations were sometimes lacking in precision.

The original magnetic observatory erected at Greenwich in the spring of 1838 was a wooden cruciform building standing about 250 ft. south of the main astronomical buildings. The first observations were of declination (D) only, but by 1840 observations of the variations in the horizontal (H) and vertical (Z) components were being undertaken. Regular observations of D were published from November 8, 1841. These were made at two-hourly intervals throughout the day and night, seven days a week. Regular observations of the variation in H and Z began in the following month. On selected days (term days) declination was read every five minutes and the other elements every ten minutes. On special occasions, during periods of magnetic storms, the time intervals were reduced to the order of a minute—in fact, visual observing became continuous and was maintained over periods exceeding twenty-four hours. This system continued until the end of 1847. During this time dip observations had been added in 1842 and absolute observations of the horizontal component in 1846, thereby establishing absolute determinations of the total field.

Such a system must have imposed a heavy burden upon the observing staff of the Royal Observatory, who doubtless welcomed the introduction in 1847 of photographic recording of both magnetic and meteorological data. The recording apparatus, which in principle is that used to-day, together with the photographic technique was developed by Charles Brooke. The results, though crude by modern standards, were successful and visual observing was reduced to calibration of the records and their measurement. Other observatories later adopted similar methods.

It is of interest to note that these early Greenwich records have in recent years provided valuable data for the statistical study of 'sudden commencements' and other magnetic phenomena.

During the period 1891–99 considerable additions were made to the astronomical buildings which interfered with the magnetic observations due to the presence of iron. A new magnetic pavilion was therefore erected in an enclosure in Greenwich Park 350 yd. east of the main Observatory. Absolute observations were thenceforth made in this new building, though the recording equipment continued to operate on the old site. But the need for new recording instruments was becoming apparent and in 1913 the erection of a new magnetograph house was begun in the enclosure 50 ft. north-west of the new pavilion. This building was completed the following year and a new set of recorders came into operation during 1915. These were maintained at a constant temperature by electrical heating thermostatically controlled. To prevent unnecessary loss of heat and to assist in maintenance of the control, the chamber containing the recorders was built upon piers within an outer building. In addition to an air space of several feet which thus surrounded this chamber, its walls were thermally insulated. By this means fluctuations in the records that would arise from changes in the moments of the magnets and in the torsional constants of the suspensions with temperature were reduced to negligible proportions.

In 1912 a dip inductor had been purchased from the Cambridge Instrument Co. This was brought into regular use in 1914 as the standard dip instrument and, combined with the new recording equipment, effected a considerable improvement in the standard of the results obtained. From 1916 mean values of declination, north and vertical components were published for every hour of the day. Values such as these, obtained over many years, at a number of magnetic observatories, have been, or are, in the process of being analysed for the determination of solar and lunar tidal effects in the atmosphere.

The improved conditions at Greenwich were unfortunately short-lived, for within ten years of the new equipment being set up electrification of the local railways had begun. In consequence, it was decided to transfer the work to a site away from London, and an observatory was built at Abinger in a wooded area on the northern slopes of Leith Hill in Surrey. New instrumental equipment was installed which included magnetometers newly developed at the National Physical Laboratory for measuring magnetic fields by electrical methods. These instruments not only greatly reduced the time taken in securing the observations necessary for the calibration of the recorders but also added materially to the accuracy of the results. Further methods, including those employing the fluxgate, have since been devised for measuring intensity of the Earth's magnetic field, but it is doubtful whether any material advance in accuracy has been attained in work of this nature.

The Abinger Observatory has now functioned for more than thirty years. During that time it has not only furnished a long series of valuable magnetic data but has also been responsible for the testing and calibrating of magnetic instruments employed in the field and at other observatories. This function was taken over from Kew when that Observatory was also compelled to discontinue magnetic work on account of local disturbances. Now Abinger itself has fallen a victim to the spread of industry and further electrification of the railway system, and refuge has been sought in the West Country at the remote village of Hartland, North Devon, twelve miles from the nearest railway. The choice of this site was governed by the desirability of retaining a magnetic observatory in the south of the British Isles. To-day it has a slight advantage over its predecessors in being farther from the observatories of Holland and Belgium, thereby slightly extending the European network. The Observatory, which remains part of the Royal Greenwich Observatory, is not yet in full operation, but continuous records of declination, horizontal intensity and vertical intensity have been maintained since the beginning of the year. By the summer of this year it should be in a position to take over completely the work of the Abinger Observatory, which includes the provision of magnetic data for mining engineers and workers in the various branches of geomagnetism.

NATURAL AND ARTIFICIAL TRACE ELEMENTS IN GEOPHYSICAL RESEARCH

THERE has been a tremendous growth of activity in the past decade in the use of trace elements in geophysical research. Particular aspects of this work have been discussed from time to time, but the first general discussion of the subject in Britain has only taken place recently at the Royal Astronomical Society, on February 1. Prof. P. A. Sheppard was in the chair and the opening speakers were Prof. H. C. Urey, who described recent work in his laboratory at Chicago, Dr. L. H. N. Cooper of the Marine Laboratory, Plymouth, who spoke on some applications of radioactive tracers to oceanography, and Dr. N. G. Stewart, of the Atomic Energy Research Establishment, Harwell, who presented evidence on large-scale atmospheric motions as provided by the deposition of radioactive dust from distant nuclear explosions.

The use of natural and artificial trace elements in geophysical research is of long standing. The physical geologist has dated the older rocks largely from the relative abundance of radioactive trace elements and their decay products. The oceanographer built up his scheme of water circulations partly from observations of salt—a dynamically active tracer—and from inactive tracers such as drift bottles. The meteorologist first inferred something of the temperature distribution in the atmosphere above 50 km. from the behaviour of meteors, and of the mean motion and large-scale turbulence of the stratosphere from the spread of dust from the Krakatoa explosion. He has also for many years studied large-scale motions from the accumulations and dispersion of water-vapour and ozone, of which there are substantial sources and sinks in the atmosphere.

The growth of such research since the Second World War has been very remarkable. For example, Kulp, of the Lamont laboratory, said in 1955 that more had been done in geochronometry in the past decade than in the previous five. The growth springs largely, though by no means wholly, from developments in nuclear physics and mass spectrometry. Thus the discovery of carbon-14 (half-life 5,600 years) in carbon dioxide and its fixation after removal from atmospheric carbon dioxide have opened up entirely new or undeveloped fields: in oceanography, the large-scale vertical circulation of the oceans and the variation of sea-level; in climatology, the advance and retreat of ice-sheets, the dating of tree-rings, the temperature of the ocean surface, etc.; in vulcanology, the dating of eruptions; and in oil technology, the mode of formation of hydrocarbons. Carbon-14 is one of several natural radioactive isotopes which are continuously produced in the atmosphere by cosmic rays. Beryllium-7 and tritium are others which, with very different half-lives, fifty-three days and twelve years respectively, are likely to become useful in meteorology and hydrology.

The stable isotopes of oxygen (oxygen-18) and hydrogen (deuterium), through their effect on the vapour-pressure of water, have found application in the study of the life-history of terrestrial water. Further, the release of numerous chemicals into the atmosphere, mainly from the ocean, has led to the chemical sampling of air and rain-water over a wide network of stations, in north-west Europe under the stimulus of Rossby. Such work may well provide oceanography, synoptic meteorology and agricultural science with new material for old problems and with new problems. Already a challenging variation in the ratio of sodium to chlorine in rain with distance downwind from a coast line has been thrown up.

Artificial trace elements have also added recently to the potential of the field. The advantage of the artificial tracer is that it can be started off at a selected time and place and with a known strength of source. One may thereby investigate motion and process on almost any scale. The nuclear bomb is of course a potent source of artificial tracers and can be a geophysical asset whatever else it may be. Early artificial tracer techniques were mainly suited to the study of small-scale motions only but the opportunity now appears for studying oceanic and atmospheric motion on a global scale.

Prof. Urey spoke on two recent applications of trace-element techniques. The first dealt with the use of the oxygen-18/oxygen-16 ratio in sedimentary marine carbonates as a quite sensitive measure of the temperature at the place and time at which the carbonates were formed. The ratio of oxygen-18 to oxygen-16 in a carbonate produced in a carbon dioxide–water system varies by a few parts in a thousand between 0° C. and 25° C., and present accuracy in measuring the ratio provides a thermometer with a probable error of about $\pm$ 0·5° C. If the time of formation of the carbonate is available, from geological evidence, or perhaps from some other trace-element technique, and if the location of the living organisms which provide the sediment can be determined, a highly valuable record of temperature as a function of time and place is produced. So far the technique has been applied to ocean-bottom Foraminifera deposited in the equatorial mid-Pacific (Emiliani 1954[1]) and to Globigerena-ooze derived from biogenous carbonate formed rather near the ocean surface in the lower latitudes of the Atlantic and Pacific (Emiliani 1955[1]). Deep-sea cores were used to provide the samples. From the former, the temperature of the bottom equatorial Pacific is inferred to have fallen more or less steadily since the early Tertiary (about 30×10^6 years ago) from 10·4° C. to its present value of 1·7° C. From the second samples, the temperature fluctuations ($\simeq \pm 3$° C.) of the near-surface waters of the lower-latitude Pacific and Atlantic have been inferred for the glacial and inter-glacial periods of the past 3×10^5 years. An attempt has also been made to correlate these variations with the variation in solar radiation in higher northern latitudes arising from the precession of the equinoxes, and the variations in obliquity of the ecliptic and in the eccentricity of the Earth's orbit. This work shows promise but is beset by many uncertainties at present.

The other work described by Prof. Urey relates to the origin of the waters of thermal springs[2]. So-called meteoric water, that is, water which has originated from evaporation at the Earth's surface and later fallen as rain or snow, has a lower deuterium and oxygen-18 content than mean ocean water because of preferential evaporation of the water molecules containing the lighter isotopes. The relative deple-

tion of deuterium and oxygen-18 depends, however, on conditions in the area in which the evaporation occurs, for example, on the isotopic composition and temperature of the evaporating water. The comparison of the isotopic composition of thermal waters with local surface (meteoric) water should therefore provide evidence on whether thermal waters have originated from or been affected by local surface water or whether, as has been supposed, some thermal waters are of magmatic origin. It has been found that all thermal waters so far examined, both from alkaline type springs and acid hot springs, show a definite dependence on the isotopic composition of the surface water. Moreover, a magmatic water of characteristic isotopic composition could not by simple mixing with surface waters acquire the range of observed characteristics of thermal waters from different springs. This work therefore gives no support so far to the idea that thermal springs may draw upon magmatic water.

Dr. Cooper spoke about a specific oceanographic problem in which a radioactive tracer could be used to effect. It was the measurement of the rather strong current which is inferred to flow on the edge of the continental shelf at depths of a few hundred metres. This current appears to arise from a gentle cascading of the relatively dense shelf waters into the deeper ocean in winter and spring. It is potentially important to fisheries because it appears to give rise to a substantial redistribution of nutrients, particularly across the main flow. The measurement of the current system, along and across the mean flow, might be made by releasing a radioactive element which is not absorbed on detritus or fractionated in the sea and preferably with a half-life of a few days. Sampling in distance, depth and time from accurately located sea stations would then be required. It will be interesting to see whether the suggestion is followed up.

Dr. Stewart described the results of sampling radioactive dust in the air and in rain, initially in the United Kingdom, but latterly on a world-wide basis. The dust produced by atom bombs is initially confined to the troposphere and is removed mainly by rain, at a rate of 50 per cent every twenty days or so. During that period the dust appears to become diffused horizontally over a substantial part of the Earth. The behaviour of the dust from hydrogen bombs is very different; much of it enters the stratosphere at burst and is only slowly diffused thereafter into the troposphere so that its half-life in the stratosphere appears to be several years. This is consistent with aircraft observations which showed that dust concentrations were a maximum in the stratosphere months after the explosions which produced the dust. It has also been found that the specific activity of rain-water varies with season in middle latitudes and decreases towards the equator. Such studies are likely to prove of great value in elucidating the nature and rate of exchange of stratospheric air with tropospheric air. Dr. A. W. Brewer made some comments on the latter problem, suggesting that the evidence from the meridional and seasonal variation of ozone implied a meridional circulation in the stratosphere and troposphere which was consistent with Dr. Stewart's findings from the activity of rain-water. Further light on this problem may come from sampling tritium and beryllium-7 in rain-water. Kaufman and Libby[3] have already reported on the former.

Dr. A. A. Smales reported on a very different line of work—the origin of magnetic spherules from deep-sea sediments and from the atmosphere and river sand. Using the technique of neutron activation, he has found that the nickel, cobalt, copper and iron content of the spherules from deep-sea sediments is similar to that of iron meteorites but that atmospheric and river-sand spherules of similar appearance are of quite different composition and more like that of some rocks. The former may well be therefore of cosmic origin, the latter probably not.

This discussion ranged widely and showed the power of new trace techniques in many geophysical fields. There can be little doubt that the techniques will be developed to two important ends: to make the statement of many existing problems, for example, climatic change, more exact, and to provide a substantial part of the solutions of other problems already well formulated.

P. A. SHEPPARD

[1] Emiliani, C., *Science*, **119**, 853 (1954); *J. Geol.*, **63**, 538 (1955).
[2] Craig, H., Boato, G., and White, D. E., Proc. 2nd Conf. Nuclear Processes in Geologic Settings. Pub. 400 (U.S. Nat Acad. Sci., 1956).
[3] Kaufman, S., and Libby, W. F., *Phys. Rev.*, **93**, 1337 (1954).

WILLIAM CHARLES WELLS, F.R.S. (1757—1817)

By Dr. J. H. S. GREEN

WILLIAM CHARLES WELLS, who was born two hundred years ago on May 24, 1757, at Charleston, South Carolina, occupies a small but definite place in the history of science and medicine which is often overlooked. His parents—Robert Wells, a printer, and Mary Wells—were emigrants from Scotland who wished, however, to retain links with their home country. William, the second son, was brought up to a Scottish allegiance. At the age of eleven he was sent over to Scotland to attend school at Dumfries, and two years later entered the University of Edinburgh for the first time, but in 1771 he returned to America.

Back in Charleston, Wells was for the next four years apprenticed to Alexander Garden (*c.* 1730–91). Garden also was the son of a Scottish emigrant, Alexander Garden (1685–1756), who had gone to Charleston as a Church of England clergyman in 1719. The younger Garden had also been educated in Scotland and, after graduating in medicine from Edinburgh, had returned to Charleston in 1752. After a year as professor at King's College (now Columbia University), New York, Garden settled as a medical practitioner in Charleston again, in 1755. Here he became a leading figure in the science of that part of America. He was a notable botanist, and corresponded with Linnæus. To his old Edinburgh professor, Charles Alston, he wrote of his "eager desire to learn something of the Nature of the herbs and their Names which the Ethiopians and Africans

use for poison and the common method of cure". He also sent over samples of drugs, and a "Description, History and Account of our Pink root" (1756) to Robert Whytt; this was the "Lonicera . . . Indian Pink root", for many years "the most widely prescribed anthelmintic in the U.S."[1]. His name is perpetuated in the *Gardenia*. Garden's support for the royalists in the War of Independence led to the confiscation of his property and he came to Britain in 1783, where he was well known, and had been elected to fellowship of the Royal Society ten years previously.

Undoubtedly Wells owed much to Garden's influence and teaching: he afterwards wrote of him as "his guide and counsellor in youth and his medical preceptor". Wells returned to Scotland at the outbreak of the war and, again at Edinburgh, studied medicine. He also studied at St. Bartholomew's Hospital and attended lectures by William Hunter. Service as a surgeon in a Scottish regiment took him in 1779 to Holland. After three months at Leyden he presented a thesis entitled "De Frigore" and, returning to Britain, graduated M.D. from Edinburgh in 1780.

Back in America he found himself saddled with the family estate and a debt of £600. As a refugee royalist he finally moved to St. Augustine, Florida, where, with a 'Printer's Grammar', a press he had brought with him, and a negro slave, he produced the first newspaper in that State[2]. At this time he appeared as an actor, basing his performances on those of Garrick that he had seen, and he also served as a volunteer captain. In May 1784, however, he finally left America with, it has been said, a lingering bitterness against that country. After a short time in Paris, Wells settled in London to practise medicine. He also held a few medical appointments—physician at the Finsbury Dispensary (1789–99), and assistant physician (1795–1800) and physician (1800–17) at St. Bartholomew's Hospital.

Wells's first published work was "An Essay upon Single Vision with Two Eyes", which appeared in 1792 and led in the next year to his election to the Royal Society. Nearly twenty years later he returned to this subject with a paper on "Observations and Experiments on Vision" (*Phil. Trans.*, 379; 1811). A number of papers dealing with more strictly medical topics were published in the *Transactions of the Medical and Chirurgical Society*. They included contributions on rheumatic fever[3], on the colour of blood (1797) and on erysipelas, which he maintained was contagious. His discussion of consumption and ague was pioneer work in epidemiology; and the observations he made on changes in the urine were of importance in connexion with the later discoveries of Bright.

Like many of his contemporaries, Wells was very interested in the experiments of Galvani, and he wrote a paper "On the Influence which Incites the Muscles of Animals to Contract in Mr. Galvani's Experiments" (*Phil. Trans.*, 1795), but he did not return to this subject. He published a number of miscellaneous biographies in the *Gentleman's Magazine*, but his most significant contributions to science were contained in two papers which suffered very different histories.

The first of these was read to the Royal Society at two meetings on April 1 and 8, 1813. It was not published by the Society, but first appeared in a volume[4] of Wells's non-medical writings published after his death. The paper contained "Some Observations of the Differences in Colour and Form between the White and Negro Races of Men". This gave what has been called "the most complete of all the anticipations of Darwin". Darwin himself, though he did not know of Wells's work until about 1865, wrote that "he applies most distinctly the principle of Natural Selection to the Races of Man". For example, Wells wrote: ". . . amongst men, as well as among other animals, varieties of a greater or less magnitude are constantly occurring. In a civilised country . . . those varieties, for the most part, quickly disappear, from the intermarriages of different families. . . . In districts, however, of very small extent, and having little intercourse with other countries, an accidental difference in the appearance of the inhabitants will often descend to their late posterity. . . . Of the accidental varieties of man, which would occur among the first few and scattered inhabitants . . . some would be better fitted than the others to bear the diseases of the country. This race would consequently multiply, while the others would decrease, not only from their inability to sustain the attacks of disease, but from the incapacity of contending with their more vigorous neighbours".

These remarks arose from his comments on a case of white pinto, that is, "a Female of the White Races of Mankind, part of whose skin resembles that of a Negro". Wells not only gave a theory of variation, selection, descent with modification, and of the origins of races of man; he also realized the importance of disease in selection—a factor not mentioned by Darwin in "On the Origin of Species". But Wells's contribution was of no contemporary significance whatever. Possible reasons for this have been discussed[5], with the conclusion: "Both Wells' achievement, and his failure to disseminate it are therefore to be explained as much in terms of his individual psychology as in relation to his cultural environment".

On the other hand, his investigation "On Dew" (1814) was by no means overlooked. This work earned him the Rumford Medal of the Royal Society, and accounts of it appeared in a number of journals ("Essai sur la rosée", *Annal. de Chemie*, 1815, 1817; "Letter on Dew", *Ann. Phil.*, 1815; *J. des Mines*, 1815; *J. f. Chem. u. Physik.* (Schweigger), 1818). It has often been treated as a model use of the scientific method and discussed in detail from that point of view—but with different interpretations. Sir John Herschel, in his early work on the philosophy and method of science—"A Preliminary Discourse on the Study of Natural Philosophy", 1831—wrote that Wells's work was "one of the most beautiful specimens we can call to mind of inductive experimental inquiry lying within a moderate compass". Later, John Stuart Mill ("System of Logic", 1841) similarly quoted it as a perfect example of logical induction—"a striking instance of the fullness of assurance which the inductive evidence of laws of causation may attain . . .". A recent discussion[6] gives an account of Wells's experiments and method.

Wells had evidently been interested for some time in temperature and effects due to changes of temperature. From James Dunsmure, a friend and patient who had been a merchant in India, he learnt of a traditional method of producing ice. Water was exposed in shallow earthenware pans at night and the loss of heat by radiation was sufficient for ice to be formed. Wells's observations on the formation of dew were largely made in the garden of Dunsmure's

home in Surrey. Previous workers, including, for example, Musschenbroek, had made observations of the phenomena; but Wells, by careful experiment, corrected a number of errors in these and put forward an explanation "which has remained substantially unaltered to the present day"[3].

Wells was not eminently successful in medical practice. It was some years before he earned a fee, after setting up in London; in the first ten years he received only £250 and his largest annual income was £764. He became a licentiate of the College of Physicians in 1798, but he had a controversy with that body and refused its fellowship. The controversy concerned the rights of membership of Scottish graduates. A letter from him to Lord Kenyon on this matter was afterwards published[4]. During his last illness, he dictated an autobiography[4] to his friend, Samuel Patrick, and died on September 18, 1817, at lodgings in Serjeants' Inn, London.

[1] Hoch, J. H., *J. of S. Carolina Med. Assoc.*, 50, No. 5 (1954).
[2] Kofoid, C. A., *Sci. Monthly*, 57, 77 (1943).
[3] Keil, H., *Bull. Inst. Hist. Med.*, 4, 789 (1936).
[4] Wells, W. C., "Two Essays: one upon Single Vision with Two Eyes; the other on Dew; a letter to Lord Kenyon; and account of a Female of the White Races of Mankind, part of whose Skin resembles that of a Negro, with some Observations on the Causes of the Differences in Colour and Form between the White and Negro Races of Men, with Memoir by himself" (London, 1818). The quotation given is from pp. 434 ff.
[5] Shryock, R. H., in "Studies and Essays in the History of Science" (ed. Montagu, F. A.), pp. 198 ff. (New York, 1947).
[6] Brown, G. B., "Science: Its Philosophy and Method", pp. 122 ff. (London, 1950).

NEWS and VIEWS

New Foreign Members of the Royal Society

THE following have been elected foreign members of the Royal Society: Hans Albrecht Bethe, of Cornell University, distinguished for his contributions to many branches of theoretical physics; Albert Frey-Wyssling, of the Swiss Federal Institute of Technology, Zurich, distinguished for his studies on ultramicroscopic structure of protoplasm and of plant cell walls; Otto Hahn, president of the Max-Planck-Gesellschaft, Göttingen, distinguished for his work on the chemistry of radioactive substances, for the discovery of several radio-elements and especially for the discovery of the fission of uranium and thorium; and Arne Wilhelm Kaurin Tiselius, of the University of Upsala, distinguished for his outstanding contributions in the field of physicochemical analytical procedures and their application to labile molecules of high molecular weight and biological importance.

Chemistry in the University of Southampton: Prof. N. K. Adam, F.R.S.

AT the end of this session Prof. N. K. Adam is to retire from his post as professor of chemistry at the University of Southampton. His association with Southampton began in 1937, when he succeeded Dr. D. R. Boyd. It had been realized before 1937 that the chemical laboratories were inadequate for university purposes and for two years before the War much work was done under Prof. Adam's guidance on plans for a new building. Plans were ready and would probably have been put into operation in 1940, but the War made it necessary to lay them aside. Early in 1947 a new plan was drawn up, and by October 1952, a few months before the University received its Charter, substantial progress had been made in completing the first stage of the building scheme. Since the War the development of the school of chemistry has been rapid. Student numbers have greatly increased, and research has been active in many directions. Prof. Adam has continued with his research students his classic studies on surface films and has secured for his department much general support from industry. The research space is now crowded, and the teaching laboratories are full. The growth of the school of chemistry and the attainment of university status by the College are due principally to a few men of faith and vision, among whom Prof. Adam must find an honoured place. His name and fame as an investigator in the field of surface chemistry and his expert writings on this subject are known throughout the scientific world. He hopes now to find an opportunity to resume his researches unhampered by heavy commitments with university affairs.

Dr. R. C. Cookson

DR. R. C. COOKSON is to succeed Prof. N. K. Adam in the chair of chemistry in the University of Southampton. R. C. Cookson, born at Hexham in 1922, was educated at Harrow School and then at Trinity College, Cambridge, where he was successively Exhibitioner, Senior Scholar, Lees Knowles Fellow, and Rowse Ball Research Fellow. He obtained his B.A. in 1944 and his Ph.D. in 1947 for research with Dr. F. G. Mann on organic compounds of arsenic. From Cambridge, Eng., Dr. Cookson made the now familiar pilgrimage to Cambridge, Mass., to spend a year working with Prof. R. B. Woodward at Harvard. On his return to England in 1949, Dr. Cookson joined the research division of Glaxo Laboratories, Ltd., whence he moved in 1951 to his present position as lecturer at Birkbeck College. Since taking up his post at Birkbeck he has rapidly attained an international reputation by his investigations. His published research has included work on the effect of the stereochemistry of molecules on their absorption of light, on natural products, especially steroids, terpenes and alkaloids and on conformational analysis. Dr. Cookson's lectures are models of lucid exposition and he has always enjoyed very happy relationships with his colleagues and his students. The Department of Chemistry at Southampton is assured of a bright future under his guidance.

Western Australian Museum: Dr. W. D. L. Ride

DR. W. D. L. RIDE, who has recently been appointed director of the Western Australian Museum, is a zoologist who appropriately has a special interest in the marsupial mammals of Australia. After studying zoology in the University of Hong Kong, where his father, Dr. L. T. Ride, is vice-chancellor, he entered New College, Oxford, and graduated with first-class honours in 1954; in the previous year he won a Christopher Welch Research Scholarship and immediately after graduation was appointed a demonstrator in the Department of Zoology and Comparative Anatomy. Recently he was awarded the D.Phil. degree for his researches into the affinities of the Macropodinæ, that is, the kangaroos and related marsupials. He has also pub-

lished accounts of a new species of fossil rodent from the Wombeyan Caves, New South Wales, and on the skull and affinities of a fossil phalangeroid marsupial, *Burramys*, from the same caves. In his work on the evolution of the kangaroos, he has employed cine-X-radiography and cinematography to assist him in his interpretations of the movement of the jaws, making studies of living wallabies taking various kinds of food. In addition to his teaching and research work in the Department at Oxford, he has taken a special interest in the collections of the Museum and has devoted much time to the cataloguing and rearrangement of the marsupial material, and of historic collections, including Burchell's South African birds and the Bell collection of reptiles.

The National Research Council of Canada

Dr. P. R. Gendron, Prof. P.-A. Giguere, Prof. L. H. J. Shebeski and Dr. F. J. Toole have been appointed as new members of the National Research Council of Canada for three years from April 1, in succession to Dr. A. N. Campbell, professor of chemistry in the University of Manitoba; Dr. G. E. Hall, president and vice-chancellor of the University of Western Ontario; and Dr. C. Ouellet, professor of chemistry and dean of the Faculty of Science, Laval University, Quebec, who are retiring. Dr. Gendron is dean of the Faculty of Pure and Applied Science, University of Ottawa; Prof. Giguere is head of the Department of Chemistry, Laval University, Quebec; Prof. Shebeski is professor of plant science in the University of Manitoba; and Dr. Toole is head of the Department of Chemistry and dean of the School of Graduate Studies in the University of New Brunswick.

Members of the National Research Council who were reappointed for a further term of three years are: Mr. G. G. Cushing, executive vice-president, Canadian Labour Congress, Ottawa; Dr. H. Gaudefroy, director, École Polytechnique, Montreal; and Prof. A. Gauthier, of the University of Montreal.

Institution of Mining and Metallurgy: Awards

The Institution of Mining and Metallurgy has announced the following awards: The Gold Medal of the Institution for 1956 has been awarded to Mr. Randolphe W. Diamond, in recognition of his distinguished services to the mineral industry in Canada. Honorary Membership of the Institution has been conferred on Mr. S. E. Taylor, for his services to the mineral industry and the Institution; on Lord Falmouth, for his services to the mineral industry, particularly in the field of education; and on Sir Ronald Prain, for his services to the mineral industry. 'The Consolidated Gold Fields of South Africa, Ltd.' Gold Medal for 1955–56 has been awarded to Mr. E. Rich, for his paper entitled "A New Process for Pneumatic Stowing: its Development and Introduction at the Rio Tinto Mines, Spain" (*Trans. Inst. Min. Metall.*, **65**); and 'The Consolidated Gold Fields of South Africa, Ltd.' Premium of forty guineas for 1955–56 to Mr. S. C. Newman, for his paper entitled "Equipping No. 3 Shaft, Harmony Gold Mining Co., Limited, Orange Free State" (*Trans. Inst. Min. Metall.*, **65**).

Hungary: October 1956

During the events in Hungary last autumn many of the universities and other bodies in the West passed resolutions in support of the Hungarian universities. Bulletin No. 8 of the Committee on Science and Freedom, dealing with "Hungary—October 1956", narrates the action taken by that Committee on receipt of a telegram from a Hungarian university on November 3, 1956, asking for its appeal for help to be forwarded to all important universities in the world. The narrative is supported by an account of the background of the Hungarian revolution by G. H. Gretton, of the twelve days of freedom by G. Fischer, of the second phase, from victory to defeat, by P. Katona, and by copies of the corporate declarations made and notified to the Committee by Downing College, Cambridge, the American Association of University Professors, the South Atlantic Modern Languages Association, Dalhousie University, Canada, the Polish Free School of Political and Social Science in London, the Free University of Berlin, the Universities of Pisa, Otago, Adelaide, Frankfurt, Friburg, Aberdeen, Washington, Oporto, Oslo, Zurich and of Istanbul, and the National Union of Australian University Students, affirming sympathy and support for their colleagues in the universities of Hungary. Copies of declarations received before the end of November were included in the document presented to the Soviet Embassy and Hungarian Legation in London on December 4, 1956, by a small group of university scholars, led by Prof. C. Darlington, acting as spokesman for the signatories.

Reactor Technology Training at Harwell

The next reactor technology courses specially arranged for senior technical executives will be held at the Reactor School, Atomic Energy Research Establishment, Harwell, during October 21–31, 1957, and January 6–16, 1958. These will be the first such courses for senior executives open to overseas as well as British students. The courses are planned to give to senior industrialists with a technical background an overall appreciation of the problems of reactor technology. The lectures will cover the physical, metallurgical and engineering problems involved in the design of power reactors and the chemical problems of fuel and effluent processing. There will also be lectures on the United Kingdom's nuclear power programme and on the organization of the United Kingdom Atomic Energy Authority and its relations with industry. The fee for a course is £50 (excluding accommodation). Selection of the students will be made three months before the start of each course. Requests for information about these and other reactor technology courses should be addressed to the Reactor School, Atomic Energy Research Establishment, Harwell, Berkshire.

National Science Foundation Grants in Science

The National Science Foundation, Washington, D.C., awarded 345 grants totalling 13,853,350 dollars during the quarter ending December 31, 1956, for the support of basic research in the sciences, for conferences in support of science, for exchange of scientific information, and for training of science teachers. This is the second group of awards to be made during the fiscal year 1957. Since the beginning of the programme in 1951, 3,166 such awards have been made totalling almost 49,900,000 dollars. The grants were made to institutions and scientists in the United States, Alaska, Canada, Great Britain, Hawaii and Puerto Rico. The research fields included are anthropology, astronomy, chemistry, biology, physics, earth sciences, engineering sciences, mathematical sciences and socio-physical sciences.

National Research Council of Canada: Scholarships, 1957–58

THE National Research Council of Canada has granted 270 scholarships for 1957–58, with a total value of 369,200 dollars. These scholarships include seventy-four bursaries worth 800 dollars each and one hundred and thirty-five studentships worth 1,200 dollars each. All these are to be held in Canada. Special scholarships awarded for study abroad include forty-one awards each worth 2,000 dollars. Of these, nineteen are tenable in the United States, nineteen in the United Kingdom and three in Sweden. Twenty postdoctorate overseas fellowships, valued at 3,500 dollars for married and 2,700 dollars for single fellows, have been granted for work in the following countries: nine in the United Kingdom, four in France, two in Germany, and one each in Belgium, Denmark, Holland, Israel and Switzerland.

Financing the National Parks

THE Financial Secretary to the Treasury, Mr. J. E. Powell, said, in a written answer to a question in the House of Commons on May 9, that no change in policy was contemplated in regard to the purposes for which the National Land Fund is used, and that the Chancellor of the Exchequer saw no reason to alter the arrangement under the National Parks Act, 1949, providing for national parks to be financed by vote, and not out of the Fund. Mr. H. H. Symonds, however, has pointed out that the main purpose of the Finance Act of 1946 was, in fact, a quite general aid to national parks, although at that date they did not yet exist. Provision was made for much greater use of the power of the Inland Revenue Department to accept land in payment of estate duty, as the Chancellor stated in his Budget speech, and the Act added "for such other purposes as Parliament may hereafter determine". It is thus now clear that the Chancellor has no intention of helping the national parks although adequate finance has never been provided by vote, and lack of finance continues to prevent the purposes of the National Parks Act being realized.

Dartmoor and Glen More

THE designation of Dartmoor as a national park marked it out as one of Britain's finest landscape areas, a national asset to be preserved for the enjoyment of the nation. The Dartmoor National Park Committee is to be congratulated, therefore, on the preparation of a guide-book which does credit to the area it describes; it has been prepared under the general editorship of Dr. W. G. Hoskins (H.M.S.O., 5*s*.). The Dartmoor Committee should also be complimented as the first park planning authority to provide an official guide-book for a national park. Glen More was established as a national forest park by the Forestry Commission in 1948 and is one of four national forest parks which lie wholly in Scotland. Under the able editorship of Prof. J. Walton a new edition of the guide originally published in 1949 has now been prepared (H.M.S.O., 4*s*.).

Coryndon Memorial Museum, Nairobi: Report for 1955

THE report of the Coryndon Memorial Museum, Nairobi, for 1955 (pp. 20+2 plates; 1956; 1*s*.), records that the easing of the situation in connexion with the state of emergency in Kenya has resulted in a marked increase in the attendance by the public at the Museum. The improvement commenced in 1954, and has greatly accelerated since then. Considerable progress is reported in the mammal habitat groups, and members of the staff have taken part in short and long field-expeditions for collecting. As in past years, the Museum is still recognized as a centre of research on Miocene and Pleistocene mammalian remains, and Dr. L. S. B. Leakey, curator, has continued his work on these subjects.

Health Education

MANY countries to-day have set up special organizations which seek to promote wider knowledge of health education. To help in the international cross-fertilization of ideas on this subject, Unesco and the World Health Organization have collaborated to produce an annotated bibliography of health education (Health Education: a Selected Bibliography. (Educational Studies and Documents, No. 19.) Pp. 46. (Paris: Unesco; London: H.M. Stationery Office, 1956.) 100 francs; 2*s*.; 0.40 dollars). The booklet is devoted to descriptive literature, the largest section containing accounts of existing health education programmes and their problems. A list of publications describing the relationship of anthropology and sociology to health education has also been included, while a section on methods and techniques deals only with publications which were specially written with health education in view.

United Kingdom Postgraduate Awards

THE ninth revised edition of United Kingdom Postgraduate Awards (Fellowships, Scholarships, Grants, etc.), 1956–57, lists awards tenable at universities in the United Kingdom or at institutions of equivalent status. To facilitate prompt reference by prospective applicants, awards open to graduates of United Kingdom universities, those open to graduates of British universities overseas and those open to graduates of universities outside the British Commonwealth are differentiated. Information, which is not claimed to be exhaustive, is also appended about some of the more important awards tenable overseas by United Kingdom graduates. The list of awards is arranged in order of subject. The pamphlet is produced by the Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.1.

Land Use in the Transvaal

THE first of the "Occasional Papers" of the World Land Use Survey to appear is Dr. Monica Cole's "Land Use Studies in the Transvaal Lowveld" (pp. 55. Geographical Publications, Ltd., 1956). That the book follows a pattern made familiar by the "Land of Britain" publications is no coincidence: the general editor of both series is Prof. Dudley Stamp. The brief, yet balanced, text treats of the physiographic and economic features influencing the distribution and character of used land, particularly in the Crocodile–Komati valley, and is augmented by, indeed often built around, the numerous illustrations—twenty-three maps and thirteen photographs—on the whole well composed (but Fig. 1 is poor, and errors are evident in the keys to Figs. 2, 19 and 34, and the caption of Fig. 24).

One regrets that seven years passed between Dr. Cole's field-work and this publication of her findings, not only because developments in this fast-changing corner of South Africa in the interval invalidate some of her statements (for example, that the Blyde basin

has now outstripped the Malelane district as the Union's premier winter vegetable-growing area), but also because official bodies and the interested public deserved to have the results of such valuable research made available more speedily. However, it is still true that, away from the older irrigation schemes established thirty to fifty years ago near rail routes in the Elands, Mid-Crocodile and White River valleys and engaged mainly in citrus production, a state of flux continues and experimentation with sugar-cane, rice, fodder crops, and a wide range of sub-tropical fruits goes on unceasingly, so that Dr. Cole's survey should not go unheeded.

Parasitic Vigour in Bacteria

D. H. Lapwood (*Ann. Bot.*, 21, 167; 1957) has attempted to relate the parasitic vigour of certain bacteria to their capacity to secrete pectolytic enzymes. Three organisms, *Flavobacterium* sp., *Pseudomonas* sp. designated No. 169, and *Pseudomonas syringae*, were compared with a pathogen, *Bacterium aroideae*. Although they all produced pectolytic enzyme of equal activity on potato extracts, only the pathogen was able to parasitize the vegetable tissue, except when the water content of the latter was increased. It was evident that success or failure of an attack was determined within 24 hr. from inoculation. The events taking place during this period were studied in some detail with potato extracts and potato tubers. On dilute extracts the pathogen grew rapidly, with an acid drift of the medium, and pectolytic enzyme was detectable within a few hours from inoculation. The weaker organisms grew slowly, with no acid-forming tendency, and showed a delay in enzyme secretion. Differences in growth and in secretion of enzyme were further accentuated when the extract approached the strength of potato sap. No obvious qualitative differences were found between the pectolytic enzymes secreted by the four organisms. The failure of the weak organisms to attack normal potato tissue can be ascribed to their slower rates of growth and enzymic secretion, which allow the host time to form a protective barrier. On the other hand, rapid growth and the secretion of enzyme within a few hours enabled *B. aroideae* to become established before a wound reaction could take place.

Forest Research in Malaya

The July 1956 issue of *The Malayan Forester* (19, No. 3; Caxton Press, Kuala Lumpur) is the jubilee number of that journal. There was a break for a few years during the Second World War; but it is a fine record to have been able to carry on throughout the recent period of troubles. Next to the *Indian Forester*, with its record of eighty-two years, the *Malayan Forester* was one of the first tropical forestry journals. Its objective has always been of a semi-technical nature. An article by H. J. Burgess, entitled "The Dissemination of Research Results", is of this type. Brief descriptions are given of the means by which research workers make their results available to their colleagues, to other laboratories, to those who can apply the information in industry and commerce, and to the general public. Publications range from university theses to trade leaflets and Press articles. It is considered that at present such reports do all that is possible to convey the results of research to those who can apply them. The difficulty, and it does not apply only to Malaya, is to reach the general public, since research publications are often couched in a form of language which is incomprehensible to the lay reader. Too often the research scientist, perhaps inevitably, becomes so enamoured of, and accustomed to, his own line of thought and work as to be unable to translate it into simple English for those uninitiated in his particular line of research, which is probably the reason why the Press is unable to give it a wider publicity.

High Temperatures

The proceedings of the symposium on "High Temperature", sponsored by the Stanford Research Institute and the University of California in June 1956, which was the subject of a report in *Nature* (178, 781; 1956), have now been published (pp. x + 218. Menlo Park, Calif.: Stanford Research Institute, 1956. 5 dollars). The illustrated and attractively produced volume contains the text of the papers presented to the symposium together with the subsequent discussion, and in addition an article, "Temperature—its Definition and Measurement", by C. Steffens, which was prepared after the symposium in answer to requests for a discussion of temperature fundamentals. There is no doubt that the symposium was highly successful. The attendance alone was several times larger than the sponsors anticipated, and it is evident from the many probing questions put to the speakers that the subject of high temperatures is widening in scope and that it is a most fruitful area for research by the mathematician, the chemist, the pure and applied physicist and the metallurgist. It is a relatively unexplored region but one which is of vital importance in this age of jet missiles, rockets and atomic energy.

Radar Evidence for Coalescence Showers

One of the major unsolved problems of meteorology is the formation of raindrops from the far smaller cloud droplets; it is known that continued condensation on individual cloud droplets cannot possibly turn them all into raindrops in the necessary time, even if enough water vapour were available. Following a theory put forward by T. Bergeron in 1933, it was once believed that raindrops were all melted snowflakes, which had grown to a large size by distillation from the cloud droplets on to a few ice crystals in a mixed cloud because the saturation vapour pressure of water is higher over water than over ice. This theory requires all clouds producing rain to extend over the freezing level. It is not doubted that the Bergeron process is effective, but rain has also been seen to fall from clouds which are entirely above freezing temperature. The only theory which has had any success in accounting for this is the coalescence theory, according to which raindrops are formed by coalescence of cloud droplets. Though there are numerous visual observations of rain from non-freezing clouds in the tropics, there have been very few from Britain. Now P. J. Feteris and B. J. Mason (*Quart. J. Roy. Meteor. Soc.*, 82, 446; 1956) report radar observations of the formation of large drops in clouds over the London area at temperatures above freezing. The radar apparatus used could detect drops only when they had reached precipitation size. The radar was trained on shower clouds which on thirteen days during the summer of 1955 revealed forty-eight separate radar echoes originating at temperatures above − 2° C. Twenty-six of these remained at a temperature above − 2° C. and fourteen afterwards extended up into the freezing part of the cloud. Some of the echoes formed

at a temperature as high as 10° C. or more. No trace of the echo from melting snowflakes which is found in radar echoes from clouds with extensive frozen portions could be seen. These observations give additional evidence of the formation of rain directly from liquid cloud particles.

Meteorites in the Yale Collections

Dr. Kurt Servos, of the New York State Museum, has published a paper on meteorites in the Collections of Yale University in Postilla (*Yale Peabody Museum*, No. 27, September 28, 1956), which records some four hundred localities where meteorites fell during more than fifty years. The data include the place, with the number of the specimen and its weight. Some readers would have welcomed further information such as date of fall or find and type of meteorite, but these have not been inserted because this information is available in such standard references as Prior's "Catalogue of Meteorites", revised by Hey. The list combines the catalogues of two major collections housed in Yale University: the Peabody Museum Collection and the Carl Bosch Collection.

Aslib Conference

The thirty-second annual conference of Aslib will be held at Scarborough during May 20–22. Members of the Association from all parts of the United Kingdom and the Commonwealth as well as other parts of the world will attend. Papers and discussions will deal with many aspects of information work. Mr. E. Martindale, of the Scottish Office of the Department of Scientific and Industrial Research, will speak on "Lines of Communication", outlining the factors which influence the flow of scientific and technical information to industry; Dr. R. E. Fairbairn, of Imperial Chemical Industries (Dyestuffs Division), will discuss the planning and growth of an information service; and Mr. B. H. P. Rivett, who is head of field investigation for the National Coal Board, will consider ways of applying work measurement techniques in information service. There will also be a short progress report on the plans for a National Lending Library for Science and Technology.

Announcements

Sir William G. Ogg, director of the Rothamsted Experimental Station, has been elected an associate member of the All-Union Academy of Agricultural Sciences in the U.S.S.R.

Mr. M. Ryle, of the Cavendish Laboratory, Cambridge, has been awarded the Hopkins Prize of the Cambridge Philosophical Society for his work on radio astronomy. The Prize has been awarded every three years since 1867 for work in mathematical–physical or related fields. The present award relates to the period 1951–54.

Open days are being held this year at the National Physical Laboratory on May 22 and 23 from 10.30 a.m. until 5.30 p.m.

The Glasshouse Crops Research Institute, Worthing Road, Rustington, Littlehampton, Sussex, is to hold an open day on June 12, when visitors will have an opportunity of seeing the present stage of the Institute's work and glasshouse experiments in progress.

A symposium on "Visual Problems of Colour" will be held at the National Physical Laboratory during September 23–25. Aspects of the subject to be covered include visual pigments, brightness and colour matching, normal and defective colour vision, subjective colour measurement, electrophysiological aspects of vision and colour theories; about thirty-five papers will be presented. Attendance will be by invitation, and those interested are requested to write to the Director of the National Physical Laboratory, Teddington, Middlesex.

The Technical Section of the British Paper and Board Makers' Association has arranged an international symposium on "Fundamental Aspects of Fibres and their Treatment for Papermaking", to be held in the lecture theatre of the Physiological Laboratory, Downing Street, Cambridge, during September 23–27. The symposium will be in four sections, dealing with the morphology of pulp fibres; the chemistry of pulp fibres; the properties of bonded fibre assemblages; and the process of beating. A registration fee of 10 guineas is charged for attendance at the conference, which will include the cost of reprints of papers to be delivered. Inquiries should be addressed to the Secretary of the Association, St. Winifred's, Welcomes Road, Kenley, Surrey.

The American Rocket Society and Northwestern University are to organize the second of a series of bi-annual symposia, to be held at the Technological Institute of Northwestern University in Evanston, Illinois, during August 26–28, when the subject will be "Transport Properties in Gases at High Temperatures and Pressures". The objects of the conference are to discuss the transport properties of gases, with particular reference to extreme conditions, to indicate present and future needs for data in design studies and promising avenues of future research, both theoretical and experimental. Lectures will be pre-printed and available at the time of the symposium. Inquiries should be addressed to Dr. Ali Bulent Cambel, Gas Dynamics Laboratory, Northwestern University, Evanston, Illinois.

The eleventh Congress of the International Scientific Film Association will be held at Amsterdam in the Royal Institute for the Tropics during September 21–27. There will be meetings of the International Scientific Film Association General Assembly, of the specialist standing committees for research films, medical, veterinary, industrial and technical films, and films for the popularization of science. Other sessions will be devoted to techniques such as infra-red cinematography, the influence of light on living microscopic structure, phase-contrast micrography, cinematographic teleregistration, and time-lapse and slow-motion cinematography. It is also expected that the Medical Committee will arrange special sessions on tropical medicine, cine-endoscopy and cine-radiography. An exhibition of photographs and equipment will also be held. Those intending to participate in the British delegation are asked to write as soon as possible to the General Secretary, Scientific Film Association, 164 Shaftesbury Avenue, London, W.C.2.

The Royal Society has prepared a new edition of its pamphlet, "Fair Copying Declaration and List of Publishing Organizations Subscribing to it", and has circulated to all subscribers to the scheme a letter explaining the position of the Declaration in the light of the new Copyright Act, 1956. The introduction to the pamphlet (p. 3) states that the new Act does not vitiate in any way the Fair Copying Declaration.

PHYSICS OF THE SOLID STATE

THE 1957 Spring Meeting of the Physical Society was held at the University of Nottingham during April 8–10, the general topic being "The Physics of the Solid State". About one hundred and fifty members and guests were present. Some twenty or so papers were given, the majority falling into one or other of the two broad categories of magnetism and semiconduction.

The meeting opened with a welcome and talk on Bitter figures by Prof. L. F. Bates (University of Nottingham), who gave a rapid, broad and well-illustrated survey of the different types of patterns which can be observed using this technique. While the underlying ideas are fairly simple, the detailed understanding of the reasons why such beautiful patterns occur is a problem of considerable magnitude. Good progress is, however, being made, and the recent development of methods for observing the patterns using the electron microscope should greatly assist. This was followed by an account of the application of neutron diffraction to magnetic problems, by G. E. Bacon (Atomic Energy Research Establishment, Harwell), in which a brief survey of the technique was followed by a discussion of some of the current and projected applications. This use of neutrons has been invaluable in helping to solve magnetic problems, and it was therefore of the greatest interest to hear about the difficulties which have to be overcome, for it is all too easy to assume that any magnetic problem can be solved by this method. In fact, the magnetic scattering is often quite small compared with the scattering from various other sources, and a good deal of very careful analysis has to be performed. It was pointed out that the study of inelastic scattering could be of particular value in deciding between the various theories of magnetism and that preliminary results were being obtained for iron. After some discussion the formal proceedings of the day ended, though the informal discussions, which form such a valuable part of these meetings, continued over sherry and dinner.

The second day's session was devoted to the magnetism of metals and alloys, a subject which was introduced by K. W. H. Stevens (University of Nottingham), who used the rare-earth metals to illustrate why there is at present so much interest in the part played by conduction electrons in magnetism. J. Owen (University of Oxford) then gave an account of his investigation, at Berkeley, of copper-rich copper–manganese alloys, using susceptibility, and electronic and nuclear resonance measurements. While the results are not yet fully understood, it appears that the manganese atoms possess large localized moments, that antiferromagnetism sets in at low temperatures, and that there is a polarization of the conduction electrons which decreases rapidly with distance from the manganese atoms. The study of this particular system has proved so rewarding that it is to be hoped that further alloys will be investigated along these lines. Although F. E. Hoare (University of Leeds) had not used the same methods, he had found anomalies in the variations with temperature of the magnetic susceptibilities and electronic specific heats, in the families of alloys of palladium with rhodium and silver, and platinum with iridium and gold. It is not clear how these can be interpreted on the band theory of metals, unless there is an exchange interaction dependent upon temperature. There was then a change to more macroscopic properties of ferromagnetic alloys, Prof. W. Sucksmith (University of Sheffield) giving an account of the remarkable properties of precipitates of fairly large ferromagnetic particles in non-magnetic matrices, with particular reference to iron–copper, nickel–gold and cobalt–copper systems. The interpretation of the data is far from easy, depending on a number of uncertain parameters, but E. P. Wohlfarth (Imperial College of Science and Technology) showed that it is possible to make substantial progress.

The next session was concerned with non-metallic magnetic systems, J. S. Smart (United States Office of Naval Research, London) reviewing Néel's theory of ferrimagnetism and recent experimental work which has so beautifully confirmed it. He directed attention to some of the difficulties about the non-vanishing of $\delta M/\delta T$ at absolute zero in some substances, and pointed out that although it had been postulated that there may be angles between spins on the same sub-lattice, this has not yet been confirmed by experiment. K. J. Standley (University of Nottingham) then gave a talk about his measurements of the dispersion of the dielectric constant and the apparent resistivity in certain ferrites. These have been made over a wide range of frequencies and at a number of different temperatures and show unexpected behaviour, which may partly be associated with the purely practical difficulty of measuring the dielectric constant when the permeability is large, but which may also indicate the existence of permanent electric dipole moments. W. Marshall (Atomic Energy Research Establishment, Harwell) gave a theoretical interpretation, using two exchange interactions of opposite signs, the dominant one being antiferromagnetic, of the observation on hydrated cupric chloride that the maximum susceptibility occurs at a temperature which is definitely above the Néel temperature. It seems that appreciable short-range order exists above this temperature, a conclusion which is consistent with the shape of the specific heat anomaly. P. L. Smith reported the results of specific heat measurements at helium temperatures on cerium ethyl sulphate and a number of chloroiridates, all of which have been studied in some detail by electronic resonance. It seems that even where a Schottky type of anomaly is expected the shape is not always right, nor is the lattice specific heat always proportional to T^3.

On the evening of April 9 the Guthrie Lecture was delivered by Prof. H. C. Urey (University of Chicago), on "Some Chemical Limitations on Theories of the Solar System". This Lecture is given annually by a distinguished scientist in memory of the founder of the Physical Society, an innovation this year being to hold it in the provinces in the course of a conference. Among those who heard the Lecture was Miss Guthrie, the founder's daughter. Prof. Urey treated his audience to a most stimulating and wide-ranging account of some of the problems which he has met in trying to interpret our knowledge about such topics as the relative abundances of the elements, the compositions of the meteorites and the theories

of the origins of the solar system, in terms of ordinary physical and chemical ideas. It was typical of Prof. Urey that although his talk was not primarily about magnetism, he nevertheless provided the experts with some rather awkward problems to think about. In the evening an informal conference dinner was held in the dining room of the recently opened Portland building.

The last day of the meeting was devoted mainly to topics related to semiconduction, with the morning's lectures largely concerned with the applications of resonance methods. By way of introduction to this, Prof. M. H. L. Pryce (University of Bristol) gave an elementary and comprehensive survey of the three techniques of cyclotron, paramagnetic and nuclear resonance. Then followed E. H. Rhoderick (Services Electronics Research Laboratory, Baldock), who gave a detailed account of a number of experiments in which nuclear magnetic resonance had been used to study some of the III–V semiconductors. In this the nuclei are used essentially as probes to examine what the electrons are doing, which means that the value of the information depends critically on the electron–nuclear coupling. The III–V compounds are a much more promising field for this type of work than are germanium and silicon, but even so it must seem at times as if Nature is being deliberately unco-operative. Cyclotron resonance was represented by D. M. S. Bagguley (University of Oxford), who reported the observation of signals at 90° and 65° K. from two types of carriers in gold-doped germanium. The masses and relaxation times were found to be independent of temperature. Due to time-table changes, the final paper in this family was given later in the day, when E. E. Schneider (King's College, Newcastle) described the application of electronic resonance and optical work to the study of alkali halide crystals. There seems to be evidence of microstructures in these, and by studying the resonances from very small amounts of divalent manganese impurities, a lot of detailed information can be obtained. For example, one of the manganese resonances is so narrow that it can only be concluded that it comes from ions precipitated on grain boundaries. In addition, we heard from G. G. Macfarlane (Royal Radar Establishment, Malvern) and R. J. Elliott (University of Reading) of some recent work which they have been doing on the interpretation of the fine structure in the intrinsic absorption edge in germanium. It appears that a number of mechanisms contribute, and a first step is to break down the observations into the parts due to the various processes. These have then been studied in detail, particularly the part played by excitons, and a very satisfactory picture of the whole phenomenon has resulted. The final contribution of the morning came from A. L. Parsons, who described his recent theories about diamagnetism.

The first part of the afternoon session was given over to the chemists, beginning with Prof. D. D. Eley (University of Nottingham) describing his work on organic semiconductors. In these, excited electrons can travel fairly freely through the molecules, but are impeded by having to tunnel from one molecule to the next. As might be expected, the energy gap is correlated with the excitation energy of the molecule. As typical of the systems being studied, we may mention metal-free phthalocyanine, the complicated substance known more familiarly to physicists as the g-marker, and some of the proteins. Then C. H. L. Goodman (General Electric Company) propounded a number of empirical rules which he has found useful in predicting new inorganic semiconductors, and described various exotic new semiconductors which he had prepared with their help, usually by substituting an A and a C atom for two B atoms, while retaining the same number of electrons. There seems to be no end to this process of producing new semiconductors, but at present it is an open question whether any of them will prove to be as valuable as the more conventional ones. In the same vein, J. C. Woolley (University of Nottingham) described his experiments on making mixed III–V compounds. The literature about this is confusing, but it now seems to be definitely established that InSb–GaSb and InAs–GaAs can be made. It takes a long time to obtain equilibrium, so that annealing over extended periods has been necessary, although recent developments seem to promise that these long times (of the order of months) can probably be much reduced.

The final session consisted of a number of short communications. J. M. Lock (Royal Radar Establishment, Malvern) described his recent susceptibility and specific heat results on some of the rare earth metals, A. E. Liddiard (Atomic Energy Research Establishment, Harwell) spoke about his work on the thermoelectric power of ionic conductors, J. H. Smith (University of Sheffield) reported on the magneto-resistance of $MnAu_2$, and S. Altmann (University of Oxford) gave a progress report on his application of the cellular method to determine the band structure in hexagonal close-packed metals.

Throughout the sessions and the social gatherings in the evenings there was a good deal of discussion and exchange of ideas, and it seemed to be the general opinion that the meeting served a useful purpose in bringing together so many solid-state physicists. The majority of the papers described work being carried out in Britain, and the overall impression was that a lot of good research is going on, but that, except possibly in some of the very largest laboratories, we are rather slow in exploiting techniques which have been recognized elsewhere as being of great potential value in solid-state physics.

No conference report is being prepared, since it is assumed that the original contributions will be submitted for publication in the usual way.

K. W. H. Stevens

INSTRUMENTS FOR USE IN OCCUPATIONAL HYGIENE

THE British Occupational Hygiene Society held its seventh conference in the Canterbury Hall, University College, London, on April 16 and 17. Eight papers were read dealing with the nature and use of instruments for guarding the health of industrial workers in the performance of their various occupations, which often expose them to potential danger if the materials they handle and their environment are not carefully controlled. Throughout the conference a broad view of the subject was taken, both by the authors and those who entered into discussion with them, and general surveys of the various techniques available, together with operational principles, featured more strongly than technical details, though the latter were by no means lacking.

The outgoing president of the Society, Dr. C. G. Warner, divisional dust suppression scientist of the National Coal Board, presided over the first day's proceedings, and was succeeded by the new president, Dr. P. Pringle, chief medical officer of the Central Electricity Authority, on the second day.

The first paper was presented by Mr. R. C. Tomlinson, of the National Coal Board, and dealt with "Sampling Programmes and Sampling Instruments". He said that the details of an experimental sampling programme are ultimately determined by three factors. First, there are the environmental conditions with their changes in space and time over which the experimenter has no control. Secondly, there is the information required—the purpose of the investigation. Over this the experimenter has some control, as he may modify his requirements if the programme would otherwise become too unwieldy. Thirdly, there is the sampling instrument, and the experimenter here has full choice from such instruments as may be available.

The greater part of the paper was concerned with a discussion of how the sampling could be arranged to fit in with these factors. It is most important to specify clearly the information required since the latest sampling and instrumental techniques often provide more efficient measurement of certain items at the expense of others. The discussion finally led to the question of what improved sampling instruments should be designed to do.

Dr. P. J. Lawther, of the Atmospheric Pollution Research Unit, then spoke of "Analytical and Clinical Methods in the Study of Atmospheric Pollution". In order to understand the harmful effects associated with dirty air it is necessary to study concurrently the character of the pollutants and the health of susceptible patients. Many complicated instruments are applied to each angle of the work but, in the last analysis, it is the effect on the human being which matters. Interpretation of this in terms of instrumental indices is so difficult that it has been found profitable to employ the human observer himself as a recording instrument. How this has been accomplished was described, together with reference to analogous experience in other fields.

Mr. C. A. A. Wass then gave an account of "Some Instruments and Instrument Techniques in Use at the Safety in Mines Research Establishment". Studies of the ways in which the safety and health of mine workers can be maintained and improved have led to the need for a wide variety of measurements and techniques, including observation and recording of phenomena associated with the development of explosions in gases and dust clouds, using high-speed cameras and devices for measuring blast (wind) speed, explosion pressures, etc.; examination of the air in mine roadways to determine the proportions of inflammable and toxic gases, especially methane and carbon monoxide; non-destructive testing and metallurgical examination of chains and other gear used for cage suspension in mines; determination of the proportions of quartz and other minerals in samples of dust from mines and from human and animal lungs; observation of the smaller dust particles by means of electron microscopes; high-speed photography of the growth or decay of flame 'kernals' initiated by small electric sparks; estimation of the concentration of respirable dust in mine air, and study of the dispersion of dust from its source. Work is needed both in the laboratory and in the mine. Instruments for use underground must be designed to stand rough usage and must be safe in inflammable atmospheres: a wide variety of such instruments have now been developed for this work.

The final paper on the first day was read by Dr. P. J. Chapman, of the National Coal Board, and was concerned with "Medical Indices in Coal Workers' Pneumoconiosis". He explained why an index of the state of disease is desirable and how the chest X-ray picture has come to be accepted as satisfactory for the purpose. In order to give an unequivocal result the film has to be of high quality, otherwise even experienced readers may interpret it in different ways. This requirement has been achieved by instrumental control of exposure and processing by methods explained in detail. Another promising index, based upon the expiration of a single forced breath, was mentioned, and two instruments for measuring it were described.

The second day opened with a paper by Dr. B. E. Dixon, of the Department of the Government Chemist, on "Field Tests for Toxic Substances in Industrial Atmospheres". He explained the need for simple, reliable tests and discussed the acceptable standards of accuracy. Certain principles of analysis are dictated by these requirements and the fundamental limitations and possibilities of improvement were described with illustrative examples.

Mr. R. A. C. Isbell, of Hilger and Watts, Ltd., then spoke on "Instruments for Use in Absorption Spectrophotometry". He stated that the design of instruments for chemical analysis depends largely on the type of product being tested. If samples were coloured, or if specific colour could be produced by some chemical treatment, a simplified form of instrument can be employed. Such an instrument uses a very simple kind of monochromator, or even colour filters. The photocells may be of the self-generating type connected directly to a sensitive galvanometer. Balanced photocell circuits enable one to be independent of source fluctuations and fatigue. Where the specific band is very narrow, or if the absorption is in the ultra-violet or infra-red region, the instrument becomes more complicated. For the ultra-violet a quartz prism monochromator and vacuum type photocells with amplification are required. This involves greater stabilization, which increased the cost of the equipment. Instruments were described in which these problems have been successfully overcome. In the infra-red region there are further problems in the selection of light source, prism material for monochromator, and detector. Instruments for routine testing are available in which particular attention has been paid to the ease of operation, so that rapid and reliable records can be obtained.

The last two papers dealt with the hazards of radiation which arose both in the atomic energy industry itself and in the many concerns applying radiating substances to their own techniques. Mr. B. S. S. Smith, of Harwell, described "Instruments in Laboratories and their Use for the Control of Ionizing Radiation". He gave a brief summary of the maximum permissible levels recommended by the International Commission on Radiological Protection and mentioned how the principles established by the Commission are used for deriving maximum permissible levels for all kinds of conditions. The physical principles of the ionizing chamber, the gas counter and the scintillation counter were outlined, and it was shown how they are used to measure the parameters of interest to the health physicist. The radiation

sensitivity of photographic materials was also described. Examples were given of how instruments incorporating the above principles are used for environmental control and for personal monitoring.

The conference came to an end after a paper by Dr. T. E. Graham, of the Windscale works of the U.K. Atomic Energy Authority, on "Diagnostic Aids in Radiation Medicine". He said that the doctor's reliance on instruments is perhaps greater in radiation work than in any other occupational field. His clinical examination reveals almost nothing unless the case is an extreme one. Radiation-induced disease has such a long latent period before it becomes clinically detectable that an early assessment of exposure is of paramount importance in prognosis. The reassurance value of negative findings is of no less importance. Techniques were described for the assessment of radiation dosage both during the exposure and after it. Radioactive contamination of the skin and problems connected with contaminated wounds were also discussed. Internal contamination and the absorption of radioactive substances present the most serious diagnostic difficulties. Here the doctor is confronted with a symptomless patient, whose history might be quite unhelpful, with perhaps only a single fact—a positive urine analysis result, for example—to guide him. Radiochemical techniques, with all their inherent uncertainty, then become the main diagnostic aids. Descriptions were given of some remarkable instruments which perform quantitative analysis of the most complex mixtures of isotopes, often present in the minutest amounts in the body and its excreta.

A full report of the conference will appear in the June issue of *Instrument Practice*. Copies can be obtained from the scientific secretary of the Society, Dr. D. J. Turner, Medical Research Council Laboratories, Holly Hill, Hampstead, N.W.3.

C. N. Davies

PHYSICS TRAINING IN SCOTLAND

THE Scottish Branch of the Institute of Physics and the Education Group joined in conference at the Royal College of Science and Technology, Glasgow, on April 12 and 13. From the first it was clear that the main concern of the conference was the proper education of the future physicist, rather than simply 'training' in physics, as stated on the programme; and, once the slight but significant differences in terminology due to the Border were understood, there was a good measure of cordial agreement between both the suppliers and demanders of physicists as to the kinds of education desired.

In his opening address, Prof. W. H. J. Childs (Heriot-Watt College, Edinburgh) said that ineffective panic measures in the future could only be forestalled by facing the fact that the shortage of trained scientific workers would be permanent, and by planning ahead in these terms. Increase in the numbers of real scientists of university calibre was unlikely, and the problem is to develop the abilities of less gifted people. He suggested for consideration a reduction in the content of undergraduate courses, and the deferment of specialized instruction to the postgraduate stage; while, at the other end, steps should be taken in the first year to fill the gaps in the knowledge supposedly acquired at school. These points were, in fact, dealt with by several speakers.

Mr. M. Milburn (Metals Division, Imperial Chemical Industries, Ltd.) spoke of the graduate physicist in industry. Versatility and an ability to apply fundamental physics logically to different types of problem were needed. Industry could provide its own specialist training; a basic understanding of physics, and some fluency in writing reports, were the qualities it sought in recruits. The needs of the Scientific Civil Service were voiced by Dr. R. A. Smith (Royal Radar Establishment, Malvern), who said that the university graduate required further training—not merely specialized training, but a postgraduate course in fundamental physics. This also was one of the points made by Mr. J. R. Atkinson (University of Glasgow), who advocated first-degree courses in pure and applied physics as university studies, with the technical colleges giving advanced postgraduate training for higher degrees, including the Ph.D. It seemed, from the discussion that centred around the role of the technical colleges, that the proud tradition of undergraduate teaching there would not willingly be exchanged for the status of a solely postgraduate school. Another of Mr. Atkinson's points—the recognition that people enter the university from school at various stages of preparedness, and the steps taken to deal with this in the first-year courses at Glasgow—raised the question of the desirability of extending university courses by a preliminary year for everyone. Prof. H. Lipson (Manchester College of Science and Technology) described the course at Manchester leading to the degree of B.Sc.Tech. Essentially, this is a course in fundamental physics, with a leaning towards engineering provided by one term's courses in engineering drawing and in workshop practice. Great importance is attached to training in essay writing. The final examination is not exclusively on matter covered by lectures, and includes a general paper on physics, and an English essay paper. To avoid overloading the students, a good deal of the more specialized theoretical work of the usual kind of undergraduate course, such as relativity and wave mechanics, is omitted.

As a relief from the day's preoccupation with purely intellectual development, the talk in the evening by Prof. Hugh Nicol (West of Scotland Agricultural College) gave much thought for food. A new factor in the world's economy had intervened at the turn of the century by the injection into the hitherto self-supporting nitrogen cycle of artificial fertilizers which needed fuel and power for their production. Food is now being grown by drawing on irreplaceable mineral resources, and though at present food–fuel consumption is only a small fraction of the whole, the way in which the use of fuel for non-food purposes makes inroads into this dwindling capital during the next few decades may be decisive later.

At the second session, Mr. A. L. Chilcot (Ferranti, Ltd., Edinburgh) described the schemes for the training of technicians. Student apprenticeship schemes undertaken by industry in conjunction with education authorities recruited people with 'higher science' and 'lower mathematics' in the Scottish Leaving Certificate, and carried training on to the level of the Higher National Certificate. Dr. G. Morris (Imperial Chemical Industries, Ltd., Stevens-

ton), the Institute of Physics assessor in Scotland for national certificates, spoke of the operation of the scheme in Scotland. Those present with some experience of assessing in these examinations may have felt that Dr. Morris possibly over-estimated their academic level as it stands at present, but endorsed his tribute to the quality and perseverance of the candidates who complete the arduous course successfully.

For the benefit of the English teachers present, Mr. J. C. Young (Paisley Academy) had to do some preliminary explanation of the Scottish school system, before giving his talk on the teacher's point of view. He spoke of the untapped resources of the junior secondary schools (the Scottish counterparts of the English secondary modern schools), and urged industrialists to take boys from these schools, and help them during their student apprenticeship days with special encouragement and guidance. Mr. D. McGill (Glasgow Academy) compared the place occupied by physics in the Scottish Leaving Certificate courses, and in the General Certificate of Education syllabuses. The Scottish system, he felt, gave a breadth and depth missing from the English system, but stopped a year too soon; the English system, in spite of its tendency to premature specialization, enabled the boy to develop generally during his last year in the sixth form. An extra year at school, with entry into the second year of the Scottish university course, would give the best of both dispensations. Finally, Mr. W. S. Gray (Scottish Education Department) spoke of recent and impending changes in the status of physics in the Scottish Leaving Certificate examination. These, ultimately giving an ordinary level examination comparable in standard with the General Certificate of Education at ordinary level, and taken at the same stage in the school career, with the upgrading of physics to a full subject, should improve the equipment with which the young apprentice begins his career, and also offer something comparable with the deeply entrenched traditional Latin to challenge (and thus attract) the ablest boys.

G. R. Noakes

SALARIES OF GRADUATES IN INDUSTRY

FOLLOWING its sample survey of graduate employment published last autumn, Political and Economic Planning has now issued a more detailed analysis* of salaries received by university men employed in industry which also examines them in relation to the graduate's faculty of study. Starting salaries of graduates who entered industry in 1950–51 were not very different from those paid to graduates as a whole, but industrial salaries four years after graduating were considerably higher than those elsewhere. Science graduates started at higher salaries than arts graduates or technologists. At the time of the survey (autumn 1954) there was little difference between the level of salaries paid to men who remained with their first industrial employer, although the scientists among them were slightly in the lead: arts graduates did considerably better than the others among those who changed their jobs, and, on average, were doing best among the graduates as a whole by 1954, though the difference (£767 compared with £736) is too slight to form a basis for firm conclusions. Scientists had then lost their initial lead of £70, but the arts men were also rather older than the scientists. Men in the oldest age-group (aged 26 or more on graduating) had increased their £20 lead to £45 at the time of the survey, and men with a first-class degree, starting with about £100 more than those with a second- or with a third-class or 'other' degree, maintained a large differential.

No correlation of significance was found between the size of the establishment and the salary-level. Mining and quarrying, oil, and chemicals and allied trades paid higher salaries, and the public utilities lower salaries at both stages, consumer goods industries paying average starting but high subsequent salaries. Industries varied most in the salaries paid to technologists: in industries in which high salaries were received, technologists started with more than arts graduates; in industries at the other end of the range they started with less, but a comparable analysis could not be made in autumn 1954, since the number of graduates in most product groups was too small. In the consumer-goods industries and the chemical and allied trades, arts graduates, and also scientists, were then receiving relatively high salaries, while in electrical engineering technologists were by then receiving rather more than scientists.

From this slender evidence Political and Economic Planning draws the conclusion that industry was not failing through its salary policy to make itself attractive to graduates. It was attracting into its ranks two-thirds of the technologists, nearly two-fifths of the scientists, and one-eighth of the arts men and a comparable proportion of men with a first-class honours degree. There is no single answer to the question whether, with some 27 per cent of the output of graduates, industry was attracting too high or too low a proportion of such men: the proportion was too low for industry, but too high from the point of view of other competitors for graduate scientists and technologists and the best type of arts men. It is not easy to tell whether the teaching profession and the Civil Service are now in a relatively stronger position as a result of recent increases in the salaries they offer. The second main conclusion drawn in the broadsheet, that the greatest advances in salary in this period were not going to the scientists and technologists, does not support any sweeping deductions. The figures relate to only one year of graduates and a mere four years of post-university employment at the outset of a career, and it would be rash to infer that the better scientists and technologists are not being brought into the management succession as frequently as the better arts men. The broadsheet seems to imply that the present salary policy offers little advantage to scientists and no advantage to technologists over arts men at the start of their career, and results in the promotion of some of the arts men to positions carrying higher salaries than those filled by any of the scientists or technologists. Even if the differential were more substantial it would be hard to assert that the policy discourages men from reading science or technology rather than arts subjects. There were too many other factors in the past encouraging the ablest school-leavers to read arts, and the figures could imply no more than that industry has found the ablest minds among such graduates.

* *Planning*, Vol. 23, No. 408: Salaries of Graduates in Industry. Pp. 45–68. (London: Political and Economic Planning, 1957.) 2s. 6d.

THE NATIONAL GALLERY

REPORT FOR 1955–56

A YEAR ago the Trustees of the National Gallery published a report describing its activities between 1938 and 1954. It has now published a report* covering the period January 1955–June 1956 which will be warmly approved by all friends of the Gallery.

Although considerable reconstruction is taking place the Trustees are finding it increasingly difficult to provide enough space to display the growing collection of pictures; it is disconcerting to learn that, since 1911, only one room has been added to the Gallery at the expense of public funds. A long-term policy is recommended which would make provision for the erection of further galleries on a site north of the present building, but immediate prospects are not encouraging. The lack of air-conditioning in some of the existing galleries is leading to serious damage of some pictures, and the Trustees hope that this deficiency will be remedied.

The difficulty of obtaining enough money to purchase outstanding pictures was clearly shown during the period under review. Although extraordinary grants were available for the purchase of El Greco's "Adoration of the Name of Jesus" and Velasquez's "St. John on the Isle of Patmos", the sums required made grave inroads into the funds available. It is heartening, therefore, to learn of the assurance given to the House of Commons by the Financial Secretary to the Treasury that a general review of museums and galleries is shortly to be undertaken. Such a review is long overdue. In 1888 the purchase grant for pictures was £10,000; by 1955 it had risen to £12,500. The request of the Trustees for an annual sum of £80,000 seems to err only in being too modest.

The work of the Conservation Department is remarkably illustrated in the restoration of Van der Weyden's "The Magdalen reading". Acquired in 1860 and examined by X-ray photography in 1927, attempts at restoration had proved unsatisfactory. In 1952 more X-ray photographs taken with modern techniques were used and, under the care of the restorer, have led to the emergence of a painting superb in its colour and detail.

The successful activities of the Conservation Department are paralleled by the growth of the Scientific Department. Although scientific research into varnishes has only just begun, there is already enough evidence to suggest that synthetic resins will eventually replace natural resins. Time alone can show the relative permanence of new varnishes, but the Ministry of Supply has undertaken an experiment by which a wide variety of varnish samples are exposed to the strong sunlight of Northern Nigeria where humidity conditions are appropriate. Tests under both fluorescent tubes and daylight are yielding data on the stability of varnishes against yellowing.

The Scientific Department has also done valuable research into the preservation of pictures. The use of electrostatic precipitators to remove dust from the atmosphere had been considered. These involve the high-potential discharge of electricity through the air with the consequent release of ozone in sufficient quantities to act upon the resins used in varnishes and the oils used in both varnishes and paint media. For this and other reasons it was decided that electrostatic precipitators should not be installed in connexion with the future extension of air-conditioning in the Gallery.

The report also contains accounts of recent acquisitions and of the work of the Publications Department, as well as a description of the arrangements for lending pictures to other galleries in the United Kingdom. The whole report, with its accompanying reproductions, has been produced with the dignity and taste which one associates with the National Gallery; it is to be hoped that the Trustees, despite financial embarrassment, will never allow their proposed annual reports to fall short of this most attractive format.

T. H. HAWKINS

* The National Gallery, January 1955–June 1956. Pp. 105+12 plates. (London: National Gallery, 1956.) 10s

THE ROYAL COLLEGE OF SCIENCE AND TECHNOLOGY, GLASGOW

REPORT FOR 1955–56

THE annual report on the one hundred and sixtieth session of the Royal College of Science and Technology, Glasgow*, besides noting the change of name, after forty-four years, from the Royal Technical College, lists the titles of theses approved for the award of the associateship of the College and for the twenty-two higher degrees of the Universities of Glasgow and of London awarded during the session 1955–56, as well as recent publications by members of the College. There are the usual reports from departments and the Glasgow School of Architecture, but a brief record of research work in progress is provided in a separate report which also includes annotated departmental lists of the more important publications during the year. Research on jets in the Department of Mathematics included investigations of the mixing of streams moving at velocities at which the effects of compressibility cannot be ignored, and an apparatus was designed for the experimental study of jet flows by means of the analogy between surface waves on shallow water and waves in a gas. The Department of Natural Philosophy continued its photoelastic examination of adhesive lap joints, and the concept of change of stress distribution due to deformation was extended to an attempt to design joints free from the undesirable stress concentrations at which failures commence. The fine structure of airborne coal-dusts is being examined with the combined techniques of electron microscopy, X-ray and electron diffraction, and a new method of measuring the absorption coefficients of highly reflecting films has been developed.

The Department of Chemistry has devoted its main effort to a study of natural products, particularly to the triterpenoid components of plants, seeds and barks. A new method was evolved for the direct micro-alkalimetric determination of sulphur in organic compounds containing nitrogen and chlorine, and photochemical studies involving ferric iron solutions are being extended. An electrochemical study of metallic silver during catalysis of hydrogen peroxide solutions has yielded important information on the nature of the surface processes, and a new method of

* Royal College of Science and Technology, Glasgow. Annual Report on the One Hundred and Sixtieth Session, 1955–1956. Pp. 60. Report on Research. Pp. 40. (Glasgow: Royal College of Science and Technology, 1956.)

studying catalyst efficiency changes, based on micro-differences of temperature, has been developed. Following a broad qualitative study of the thermal breakdown of saturated polyesters of the 'Terylene' type, by way of model systems, the Department of Technical Chemistry commenced a more quantitative investigation of the mechanism of the competitive scissions observed, and is extending the programme to unsaturated polyesters of the maleate–fumarate type. Marked progress was made in a study of the photochemistry of dyestuffs adsorbed on polymeric substrates, and the mechanism of drying of natural vegetable materials is being further investigated, along with the diffusion of soluble components in such systems. Promising results were obtained in a preliminary study of industrial vacuum crystallization. The chief emphasis in the Department of Metallurgy was on the determination of activities of the various reactants in slag/metal relationships.

Sponsored research for the British Shipbuilding Research Association, the Cold Rolled Sections Association and large industrial firms continued in the Department of Mechanical, Civil and Chemical Engineering, together with short-term investigations over a wide field for local industry. The Department of Electrical Engineering extended its study of the criteria for the development of a power arc in the path of a surge discharge on an energized system to include the effect of the point on the a.c. wave at which the surge is applied, and also continued an investigation of the behaviour of servo-mechanisms with backlash which has led to the discovery of the generation of sub-harmonic oscillations in such systems. Work on an automatic control system for motor-generator sets achieved a frequency stability of $\pm$ 0·05 per cent, a special form of conductivity bridge was developed and constructed for the West of Scotland Agricultural College and a resistance divider for 200 kV. was completed. The Department of Mining Engineering completed full-scale trials with the electric analogue ventilation network computer, the School of Pharmacy and Department of Food Science completed its survey of the epidemiology of cat tapeworms in Scotland and continued its work on bacterial polysaccharides, on the constituents of *Leontice leontopetalum* and on the assay of wheat and soya lipoxidase by diffusion. In the Department of Textile Technology work is in progress on the mechanical properties of knitted glass laminæ and the sorption of vapours by textile materials in high vacuum.

CHILDREN AND FILMS

In an address to the Royal Society of Arts, Miss Mary Field, executive officer to the Children's Film Foundation, described investigations which have led to the making of special films for children*.

Two sharply divergent points of view are held with regard to children's films. The Soviet bloc and most of Europe believe that children at the cinema should be sheltered from the actualities of life. They should be provided with cartoon or puppet films which show them a fairy-tale world of fantasy or else with films with a direct moral purpose such as "stressing the value of human labour". On the other hand, the Americans, who do not make special children's films, believe that children are essentially little adults and are perfectly ready to take adult screen entertainment. Neither of these divergent points of view is accepted in Britain, where it is believed that, to get the greatest pleasure and profit in the cinema, children should see specially produced films within their understanding and experience, and these should be mainly realistic. Instruction should play a subsidiary part to entertainment.

The unique contribution of the British venture to children's films is that it has been undertaken by the film industry itself. The audience which sees British children's films has to pay to see them. This has meant that the films have had to be sufficiently entertaining for children to want to see them in competition with cowboy or space films which may be showing in a rival cinema. It has therefore been necessary for British producers to study, more carefully than those of any other country, the actual response of children to films.

The child at the cinema ceases to be an individual while the film is showing, and becomes part of a group. The moment the lights go up again and the film is over the child loses contact with the group and, if questioned about his reactions to the film, is unable to recall exactly what they were at any particular moment.

The British method of inquiry has been to observe the audience as a whole, either by standing to the side of the cinema in the front of the audience and looking back over perhaps two thousand uplifted faces, or, for purposes of record for discussion, by photographing a random group of an audience at certain points of the film by infra-red photography. The object of this photography is to find out the children's responses to technical problems, such as the development of the plot by dialogue, the effects of music or of camera movement. A system has been evolved by which cinema managers, who are skilled observers of audiences, fill in reports on how a film has been received by their cinema club. The responses are often divergent, showing a clash of opinion between audiences in different parts of the country and between different social groups. One cinema in the North of England, for example, found a story of a film weak, while another group in the Midlands found that the uncomplicated plot was easy to follow. More severe criticisms were that one film should be remade entirely, whereas other managers reported that the same film was excellent. The managers' reports give a general overall picture of the film taste of children in Great Britain and, in spite of divergences, there is sufficient similarity to extract a highest common factor of cinema entertainment for children.

This kind of practical consideration of child audiences has enabled British film producers to make films which are highly acceptable to children in every part of the world, although perhaps not always so acceptable to those adults who believe that children's entertainment should always have a definite moral value.

British producers start with the assumption that children's cinema taste is naturally good before it becomes perverted by seeing too many grown-up films which they cannot understand. It is easy to bore children by putting before them films in which the plot, the characterization and the motivation are beyond their understanding.

First, the attention of the child audience must be caught with action and a compelling sound track. The plot must be stated immediately, the main

* *Journal of the Royal Society of Arts*, **105**, No. 4999 (March 15, 1957).

characters introduced and their roles indicated or sharply suggested. The story of a children's film must be a story which they can understand, and the characters must be characters with whom they can identify themselves. Children are really interested only in children like themselves or in attractive animals; they have little interest in adults and few cowboys would be popular if deprived of their horses. However, very old people who are approaching their second childhood compel attention.

The plot has not only to be closely integrated—it needs to be told in pictures rather than in dialogue. The scenario must be planned so that all the dialogue essential to the plot is either said by the film children or heard by film children.

Casting actors for a children's film is somewhat different from casting for adults. The children must appear to be real children, not juvenile 'stars'. Children have their own ideas of what a film adult should look like. Men should be tall, thin and somewhat hatchet-faced, while women should be slim and attractive, but by no means too glamorous. All parents, school-teachers, policemen, clergymen, Civil servants and others whom it is hoped children will respect should be under the age of thirty.

What should be the content of a children's film? How far should it be entertainment and how far instruction? Direct instruction should be ruled out and reserved for school hours and the therapeutic value of laughter and adventure be remembered. From the age of six onwards, children are seeking more and more contact with reality before they return once again into a dream world, this time that of the adolescent. In order to get some sense of security in the strange adult world, children like to believe that good will win in the long run and overcome evil.

Are children frightened by films? Children are much tougher than is generally believed, and they have excellent ways of defending themselves from what is frightening, such as shutting their eyes, putting their coats over their heads, playing on the floor, even turning their backs on the screen. Most children, however, are really distressed by seeing a child who is frightened or ill-treated and such identification with screen characters extends, in Great Britain, to animals as well.

The real danger to children in the cinema lies in the adult films to which they are taken by their parents and which do not so much frighten them as bore them, since the stories are not within their comprehension. After a long diet of adult films, children give up trying to use their intelligence at the cinema and are content only to have their emotions stirred. But, since films are a part of our modern culture, it is important that young people should learn to understand them and also to appreciate the technique of the cinema.

POLARITY OF WHALE OVARIES

By Dr. R. M. LAWS
National Institute of Oceanography, Wormley, Surrey

THE corpora albicantia of the ovaries of fin whales (*Balaenoptera physalus*) and blue whales (*B. musculus*) are accumulated at a fairly constant rate and persist throughout the life of the animal, regressing to pale scars, seldom less than 1·5 cm. in diameter. They are then composed of a tangle of thick-walled sclerotic blood vessels, and no evidence of further resorption has been observed in histological sections. As many as fifty-four have been observed to accumulate in the ovaries of a single whale.

In recent years I have examined some hundreds of pairs of whale ovaries collected in the Antarctic and preserved in formalin. Owing to their large size (on average the ovaries of a pregnant blue whale together weigh about 15 lb. and of a pregnant fin whale about 6 lb.) it was found convenient to cut transverse serial sections, 5 mm. thick, on a commercial bacon-slicing machine, and the corpora lutea and corpora albicantia were observed and counted before pieces were taken for histological examination.

The primary purpose of this investigation was to obtain counts of the numbers of corpora for the estimation of age.

The ovaries usually have a flattened, elongated egg-shape, tapering slightly towards one end[1]. At an early stage it became apparent that the corpora albicantia were not distributed at random, but were grouped towards the thicker end. It has been possible to determine the orientation of thirty fin whale ovaries because the ligamentum ovarii and the mesovarium were still attached near the posterior pole, and the plica diaphragmatica close to the anterior, or cranial pole[2]. In this sample the anterior pole is at the thicker end.

In the routine slicing a number of ovaries were first divided arbitrarily into two halves and each half was examined separately. Altogether, 394 fin whale ovaries and 252 blue whale ovaries have been examined in this way. Choosing only those ovaries with more than six corpora, and testing the difference between the two halves by means of χ^2, the probability that the corpora are not randomly distributed is found to be highly significant ($P < 0{\cdot}01$). For the total sample of fin whale ovaries there are on average 4·29 (or 78·7 per cent) corpora in part I (the thicker end), and only 1·16 (or 21·3 per cent) in part II. For blue whales the corresponding figures are 4·69 (or 71 per cent) and 1·92 (or 29 per cent). Considering 65 fin whale ovaries with ten or more corpora, the proportions in the two halves are 76 and 24 per cent. Of 50 blue whale ovaries with ten or more corpora, the proportions are 65 and 35 per cent. This suggests that there is little change with age. In the accurately orientated sample of fin whale ovaries the average number of corpora in the anterior half is 4·57 (or 74·1 per cent) and in the posterior half 1·60 (or 25·9 per cent), which is in close agreement with the unorientated sample.

In fact, the distribution is even more asymmetrical, because the corpora found in the posterior half are usually grouped near the dividing line and the posterior third of the ovary is usually without any corpora albicantia. Moreover, in 11·5 per cent of blue whale ovaries with two or more corpora, and 32·7 per cent of fin whale ovaries with two or more

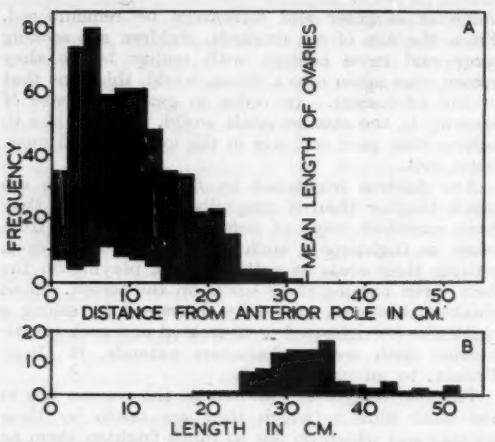

Fig. 1. (*A*) Distribution of corpora lutea (white) and corpora albicantia (black) in relation to the anterior pole; 96 fin whale ovaries. (*B*) Length frequency of these ovaries

corpora, they are entirely confined to one half of the ovary. In 20 per cent of the orientated fin whale ovaries with two or more corpora, they are confined to the anterior half.

More precise evidence is available from the examination of 96 fin whale ovaries for which scale drawings were made, showing the position of the corpora in relation to the longitudinal axis of the ovary. The assumption is made that the anterior pole is at the thicker end of the ovary, which also usually has most corpora. Then the distance from this pole to the centre of the individual corpora has been measured to the nearest centimetre and the frequency distribution of corpora along the axis of the ovary has been plotted for 2 cm. groups (Fig. 1). This shows a progressive decline in frequency of corpora at increasing distances from the anterior pole, and they are completely absent from the posterior third of the largest ovaries.

We may conclude that the corpora albicantia are grouped towards the anterior pole of the ovary. This asymmetry is more striking in fin whales than in blue whales, and it implies that ovulation generally takes place from the anterior part of the ovary, which lies in close relation to the ostium abdominale. For 47 of these fin whale ovaries the distribution of corpora lutea has been obtained. They are also indicated in Fig. 1 (excluding the accessory corpora lutea) and show a similar polarity, all being confined to the anterior 13 cm., with an average distance from the anterior pole of 6·5 cm. Accessory corpora lutea occur at distances of 4 cm., 5 cm., 9 cm., 16 cm., 23 cm. and 25 cm. from the anterior pole, in three ovaries.

Outside the Cetacea, I am unaware of the occurrence of this phenomenon in any other mammal except the mare. Harrison[3] and Comrie and Adam[4] state that the site of ovulation in the odontocetes, *Globicephala melaena* and *Pseudorca crassidens*, appears to be situated anywhere on the surface of the ovary. According to Kupfer[5], in young mares follicles are continually being formed at the cranial pole and this is at first the usual place for ovulation to occur. There the edge of the fimbriated funnel is attached and there the superficial connective tissue, which is tough elsewhere, is thin. The ovulation fossa is a secondary formation, owing to growth of the poles causing deformation of the ovary and the development of tough connective tissue over the surface except for the ovulation fossa. Hammond and Wodzicki[6] state that serosa covers the surface of the adult ovary except for the ovulation fossa, which has a layer of short polygonal cells, a remnant of the germinal epithelium. Small follicles are evenly distributed through the stroma but migrate towards the fossa as they mature.

There is no direct evidence on this point in the whale. Follicles averaging 1–2 cm. in diameter are usually distributed throughout the ovarian cortex in both pregnant and non-pregnant mature females, with no noticeable grouping towards one pole, and it is difficult to believe that such large follicles migrate. An alternative explanation is that usually only follicles in the anterior part of the ovary mature and ovulate. The largest follicles (as well as the corpora lutea) are found in the anterior half. In the course of the routine examination, the diameters of the largest follicles in each half of 205 fin whale ovaries were measured; in fifty there was no difference between the two halves, in forty-five the largest follicle was in the posterior half and in 110 the largest follicle was in the anterior half. Subjective observations on the distribution of Graafian follicles in 160 fin whale ovaries (recorded as: "many", "moderate numbers", "few", "very few") show that 120 are noted as having equal numbers in both halves, in nine there were more in the posterior half and in thirty-one the majority were in the anterior half.

The ovary of the newborn whale is completely covered by germinal epithelium. Two immature Antarctic fin whale females 54 ft. and 56 ft. long were found to have very many primary follicles in the superficial part of the cortex; they are already separated from the germinal epithelium by a tunica albuginea which is respectively about 150μ and 250μ in thickness. Sexual maturity is attained in Antarctic fin whale females at an average length[7] of 65·5 ft. Sections of the ovary of a mature female of length 69 ft. already show a conspicuous tunica albuginea 1·2 mm. thick, and no primary follicles have been seen in histological preparations. This applies to all larger females examined.

The tunica albuginea is so conspicuous that it can be measured macroscopically in the 5-mm. thick slices, at varying distances from the anterior pole. For eleven fin whale ovaries it appears to increase in thickness from about 0·95 mm. at the anterior pole to about 1·6 mm. in the posterior half. This suggests that ovulation may be mechanically suppressed in the posterior part of the ovary, because maturation might be more rapid where the tunica albuginea is thinner, as in the mare. The similarity between the mare and the whale reminds one of the widely held view that the Cetacea and Ungulata are derived from a common ancestral stock.

I would like to thank my colleagues, Mr. D. E. Cartwright, Dr. R. G. Chittleborough, Mr. A. E. Fisher and Mr. J. Smoughton, for their help.

[1] Mackintosh, N. A., and Wheeler, J. G. F., Discovery Reports, **1**, Plate XI, Fig. 3 (1929).
[2] Ommanney, F. D., Discovery Reports, **5**, 363 (1932).
[3] Harrison, R. J., *J. Anat., Lond.*, **83**, 238 (1949).
[4] Comrie, L. C., and Adam, A. B., *Trans. Roy. Soc. Edin.*, **59**, 521 (1938).
[5] Kupfer, M., Union S. Africa, Dept. Agric., Dept. of Vet. Education and Res., 13th and 14th Rep., 1211 (1928).
[6] Hammond, J., and Wodzicki, K., *Proc. Roy. Soc.*, B, **130**, 1 (1941).
[7] Mackintosh, N. A., Discovery Reports, **22**, 197 (1942).

A NEW SERIES OF PHENAZINES (RIMINO-COMPOUNDS) WITH HIGH ANTITUBERCULOSIS ACTIVITY

By VINCENT C. BARRY, J. G. BELTON, MICHAEL L. CONALTY, JOAN M. DENNENY, DEIRDRE W. EDWARD, J. F. O'SULLIVAN, DERMOT TWOMEY and FRANK WINDER

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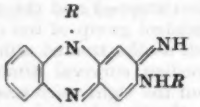
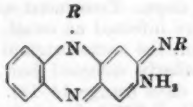
IN previous communications[1,2] we have described the preparation and antituberculosis properties of two series of isomeric phenazine pigments which are obtained by oxidation of derivatives of *o*-phenylenediamine with ferric chloride or *p*-benzoquinone. These have the general formulæ, I or II.

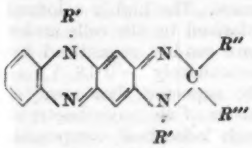


I (R = Aryl)

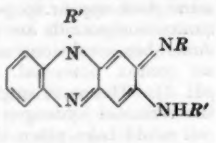


II (R = Alkyl, *cyclo*alkyl, aryl)

When R = .$C_6H_4Cl(p)$, both (I) and (II) have shown antituberculosis activity in mice which, measured by increased survival time, is of the order of that obtainable with isoniazid[3]. When the oxidation of the *o*-phenylenediamine derivative is carried out in the presence of certain ketones a new type of glyoxalinophenazine, III, is obtained which on catalytic hydrogenation gives imino-substituted compounds (rimino-compounds) of type IV. These rimino-compounds may also be obtained in certain instances by direct reaction of compounds of type I with the appropriate primary amine. (The formula previously given[3] for type IV compounds is incorrect.)



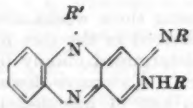
III



IV (R = .$CHR''R'''$)

Thus =NH in I may be readily replaced by =N.$CH(Me)_2$, =N.C_6H_{11}(*cyclo*hexyl), =NPh, etc. Reaction of type II phenazines with aromatic amines can also give rise to rimino-compounds by replacement of NH_2 by NHR.

Other rimino-compounds, V, have been obtained by condensing *o*-phenylenediamine derivatives with diarylamino-*o*-quinones using a modification of the synthetic method of Kehrmann and Cordone[4]. Using this method it has been possible to synthesize certain rimino-compounds not accessible by the routes already described. The chemistry of these compounds will be published elsewhere, and the remainder of this article is concerned with the remarkable biological properties of one of these derivatives, *B*.663 (IV, R = $CH(Me)_2$; R' = $C_6H_4Cl(p)$), with which most of our investigations to date have been concerned.



V (R = aryl)

Some results obtained in the treatment of murine tuberculosis are shown in Table 1. Briefly, the methods[5] used in screening for antituberculosis activity in mice were as follows: groups of 8–10 albino mice were infected intravenously with the isoniazid-sensitive Ravenel *Rv* bovine strain of *M. tuberculosis* or with an isoniazid-resistant variant (resistant to 100 μgm./ml.) of that strain. Drugs were administered in the diet (*a*) for 14 days commencing on the day of infection, that is, 'protective screening', (*b*) for 14 days commencing on the sixth day after infection, that is, 'established disease screening', and (*c*) as in (*a*) but employing the isoniazid-resistant variant.

Median survival times of the control groups (both isoniazid-sensitive and -resistant) were of the order of sixteen days.

It will be seen that *B*.663 is more active than isoniazid on a weight-for-weight basis and very much more active on a molar basis. The activity is, of course, greater than any we have observed with other antituberculosis substances such as *p*-aminosalicylate, streptomycin or the thiosemicarbazones.

B.663 also showed a striking effect in established tuberculosis of guinea pigs. For this screening, guinea pigs of 460 gm. average weight were infected subcutaneously with the isoniazid-sensitive Ravenel

Table 1. *B*.663 IN TUBERCULOSIS OF MICE

Drug	Type of screening	Daily intake of drug (mgm./kgm.)	Increase in median survival time over controls
B.663	Protective screening	119	+ > 241
	,, ,,	20	+ > 210
	,, ,,	8	+ > 210
	,, ,,	5	+ 220
	,, ,,	2	+ 95
	,, ,,	1	+ 1
	Established disease screening	180	+ > 250
	,, ,,	60	+ 200
	,, ,,	11	+ > 80
	Protective screening using the isoniazid-resistant variant	3·3	+ > 133
Isoniazid	Protective screening	25	+ 150
	,,	3·7	+ 7
	Established disease screening	39	+ 67

Table 2. *B.663* in Tuberculosis of Guinea Pigs

Group	Disease Index (Max. possible = 100)	Mean daily intake of drug (mgm./kgm.)
Precontrols Killed after 21 days	35, 35, 50, 50, 50 Mean = 44	—
Controls One died on 53rd* day and one on 89th† day, both from tuberculosis. Remaining seven killed after 100 days	80, 80, 100, 50, 80, 100*, 100, 90†, 90 Mean = 85·6	—
Established disease group Treatment starting on 21st day after infection. All killed after 100 days	10, 15, 5, 5, 5, 5, 20, 10, 5, 5 Mean = 8·5	144

strain. Commencing three weeks after infection, the drug was administered in the diet for eleven weeks.

Activity was determined mainly by the change in the 'disease index'. Extensive disease in the lungs, liver, spleen and site of inoculation plus adjacent lymph nodes was awarded 35, 30, 25 and 10 points respectively. Moderate disease was awarded 25, 20, 15 and 10 points and slight disease 15, 10, 5 and 5 points[5].

It will be seen in Table 2 that guinea pigs with a disease index 21 days after infection of 44/100 had, at the conclusion of the experiment 79 days later, their disease index reduced to 8·5/100. Except in six cases where the spleens showed occasional well-circumscribed tubercles, any macroscopic disease left at that time was confined to the site of infection and to the regional lymph nodes for that area. The minced tubercle-free spleens were injected into guinea pigs without producing tuberculosis; the tubercle-containing spleens did so in all cases. None of the lungs from the ten treated guinea pigs showed macroscopic evidence of tuberculosis, although portions of lungs from five of these animals did cause tuberculosis in guinea pigs. Four of the five lungs which failed to cause tuberculosis were from those guinea pigs in which the spleens behaved similarly.

The group of mice (Table 1) which received 119 mgm./kgm./day of compound *B.663* for 14 days, commencing on the day of infection, is particularly interesting. The median survival time of the controls in this experiment was 13·5 days. One mouse of the treated group was killed 198 days after infection. It showed no macroscopic evidence of tuberculosis and therefore a brei of its lungs was injected subcutaneously into two guinea pigs; both failed to develop tuberculosis. On the 241st day after infection, the remaining nine treated mice (mean weight, 35·0 gm., as against initial weight of 29·9 gm.) were killed. No macroscopic evidence of tuberculous disease was found in any of these mice. One lung and half of the spleen from each mouse were then minced and used to inoculate slopes of Löwenstein–Jensen medium, which were incubated for twelve weeks. The remaining minced lung was used for subcutaneous injection into the left inguinal region and the other half of the spleen into the right inguinal region of the same guinea pig. The nine guinea pigs were killed 186 days after injection. Negative results were obtained for four of the nine mice (that is, a total of five out of the group of ten) on both culture and guinea pig inoculation.

B.663 accumulates in the tissues of mice and guinea pigs. In the latter, treated for some weeks with doses of the order of 100 mgm./kgm./day, the fatty tissues are stained an orange colour and the other tissues are stained a varying depth of red, in some cases almost black. The drug was extracted from the minced organs, and appears chromatographically to be unchanged. Guinea pigs treated with *B.663* (0·2 per cent in the diet) for four weeks had a concentration of 0·5 per cent in the lungs and 0·08 per cent in the subcutaneous and other body-fat. Mice fed 0·1 per cent in the diet for six weeks yielded 0·16 per cent in the lungs.

Histological examination showed deposition of crystals of the drug in the jejunum and ileum; in the liver, spleen, lungs and kidneys. There was little evidence of toxicity, apart from foreign-body reaction and changes due to circulatory disturbance caused by the crystalline emboli. However, antituberculosis activity is exerted without crystal deposition in the tissues, for example, with a dose of 2 mgm./kgm./day for fourteen days, as shown in Table 1.

This property of deposition in tissues prompted us to carry out a prophylactic experiment. Mice were treated with 5 mgm./kgm./day of *B.663* for 38 days. Treatment was then stopped and the mice were infected as usual. A control group of ten mice from the same original batch as the treated animals similarly infected had a median survival time of 15 days (range 14–18). From the eight mice treated with *B.663* before infection, the first death occurred on the 111th day; two are still alive 220 days after infection (median survival time about 120 days). Other experiments on these lines now in progress show that a dosage schedule of 10 mgm./kgm./day for fourteen days, terminated as long as four weeks before infection, confers protection.

In Proskauer and Beck medium enriched by 5 per cent human serum, *B.663* inhibits the growth of *H37Rv* for fourteen days at a concentration of 0·8 μgm./ml. At this concentration, the compound is strongly taken up by living mycobacteria (2 mgm. per gm. dry weight). This may be important in explaining the effectiveness of *B.663* at low concentrations. How much of the 'adsorbed' compound is held within the mycobacterial cell is uncertain, but some does appear to penetrate. The highly coloured rimino-compounds are decolorized by the cells under anaerobic conditions and are readily reoxidized by air (redox potential, approximately −0·18 V. at *p*H 7). Hence it might be expected that some of the terminal hydrogen transfer of the mycobacterial cell could take place through 'adsorbed' compound. This was confirmed by showing that the respiration of *M. smegmatis* is reduced to 10 per cent of normal by *M*/100 cyanide but only to 30 per cent of normal when *B.663* was present at the minimum growth-inhibitory level. Thus 20 per cent of the respiratory hydrogen can be transferred from a respiratory enzyme to *B.663*. The enzyme concerned is not known, but a flavoprotein seems probable.

It is not yet clear what part this withdrawal of hydrogen from the respiratory chain plays in the anti-mycobacterial action of the rimino-compounds. Even if 20 per cent of the terminal respiration takes place through them, it would lead at most to a 20 per cent drop in oxidative phosphorylation. It would not be expected that this degree of interference would result in complete inhibition of cell growth, although the possibility cannot be discounted entirely.

The involvement of the rimino-compounds in respiration has a further consequence, however. As with other redox dyes, when the reduced form is re-

oxidized by oxygen, the formation of hydrogen peroxide can be shown. The formation of peroxide has also been demonstrated when living cells or cell-free-extracts of *M. smegmatis* or *M. tuberculosis* were incubated aerobically with *B.*663, azide being added to inhibit catalase, and in the absence of azide when a 'catalase-negative' strain of *M. tuberculosis* was used. Again, however, it is not clear how far this peroxide formation is responsible for the action of the rimino-compounds. It would appear to be responsible for the rapidly progressive inhibiting effect of *B.*663 on mycobacterial respiration in the presence of a catalase-inhibiting level of azide (although neither azide nor *B.*663 alone affects the respiration until a very much longer period has elapsed). The peroxide formed in the external medium, however, in the presence of *B.*663 is insufficient in amount to account for the growth inhibition. On the other hand, peroxide formed by the compound within the cell may be very much more toxic. The following evidence suggests that peroxide formation may play at least a part in the action of the rimino-compounds. 'Catalase-negative' (isoniazid-resistant) strains of *M. tuberculosis* are more susceptible to *B.*663 than are the parent 'catalase-positive' strains. Sub-inhibitory levels of azide decrease the concentration of *B.*663 necessary for growth inhibition.

Finally, when *M. tuberculosis* is inoculated into a dilution series of *B.*663 in a semi-solid medium[4], growth is obtained at the surface at non-inhibitory concentrations, but when the inhibitory concentration is approached, growth takes place some distance below the surface. This could be explained on the grounds that, at the lower oxygen tension in the depth of the medium, *B.*663 is able to transfer less hydrogen to oxygen and hence to form less peroxide.

Grateful acknowledgment is made to Arthur Guinness, Son and Co. (Dublin), Ltd., and to J. R. Geigy S.A., Basle, for financial support.

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EFFECT OF CERTAIN NUCLEIC ACID COMPONENTS UPON THE STATUS OF IRON, DEOXYRIBONUCLEIC ACID, AND LIME-INDUCED CHLOROSIS IN FRUIT TREES

By Dr. B. KESSLER
Agricultural Research Station, Rehovot, Israel

IN the course of a study of the metabolism of nucleic acids, a close relation was found between the level of nucleic acids and the status of inorganic nutrients in fruit trees. Thus it was found that the addition of adenine and guanine causes an increase of deoxyribonucleic acid and brings about changes in the status of iron in the leaves. No such changes were brought about by uracil, cytosine and xanthine.

Leaves of grape vines (var. Madeleine Oberlin on 41-*B* stock), olives (var. Souri), peach (var. Elberta on almond stock) and plum (var. Kelsey on almond stock) trees were sprayed with 50 p.p.m. solutions of adenine and guanine. Treatments were carried out on two branches each (in the case of grape vines the whole plant was used) and with five replicates. Two weeks after spraying, leaves were collected for analysis. Nucleic acids were extracted from fresh material with 1 *N* perchloric acid[1] at 37° C., and were fractionated with 0·35 *N* sodium hydroxide at 20° C. Deoxyribonucleic acid was then precipitated in an acidified solution and determined spectrophotometrically[2]. For the analysis of iron, leaves were carefully washed, first with an acidified detergent and then four times with glass-distilled water. 'Soluble' iron was extracted with 1 *N* hydrochloric acid; both soluble and total iron were analysed by a modified method[3] of Stokes and Cain[4] which was further modified in this laboratory (Moscicki, W., unpublished work). The adenine and guanine sprays were found to increase the concentration of deoxyribonucleic acid in the leaves, which in turn was rather closely paralleled by the soluble-iron fraction as shown in Table 1.

Table 1. Effect of Adenine and Guanine upon Deoxyribonucleic Acid and Iron Fractions in Leaves of Fruit Trees

Species	Treatment	Deoxyribonucleic acid (per cent of dry matter)	Iron (p.p.m. of dry matter)			Soluble iron as percentage of total
			total	soluble	insoluble*	
Olive	Control	0·12	60	39	21	65·0
	Adenine	0·27	125	79	46	63·0
	Guanine	0·25	122	72	50	59·0
	Mustard gas	0·08	113	20	93	17·7
	S.E.†		1·93	2·20		
Plum	Control	0·27	184	27	157	14·7
	Adenine	0·68	102	83	19	81·4
	Guanine	0·48	130	82	48	63·0
	S.E.		4·03	2·87		
Peach	Control	0·35	70	26	44	37·0
	Adenine	0·58	60	47	13	78·3
	Guanine	0·72	68	54	14	79·5
	S.E.		1·59	2·69		
Grape	Control	0·38	54	21	33	38·8
	Adenine	1·17	58	58	0	100·0
	Guanine	0·98	59	55	4	93·0
	S.E.		2·75	2·28		

* The insoluble fraction was calculated as difference between the total and the soluble fraction.
† Standard error.

Table 2. Correlation Coefficient and b-Values of Fig. 1 between Deoxyribonucleic Acid and Soluble Iron

Species	b*	S.E.†	r‡
Olive	232·7	3·74	0·98
Plum	122·0	14·04	0·95
Peach	75·2	5·71	0·75
Grape	52·6	3·25	0·98

* Calculated slope.
† Standard error.
‡ Correlation coefficient.

In order to examine more closely the relation between deoxyribonucleic acid and iron fractions, undetached leaves of grape vines were immersed for 10 sec. in an aqueous solution of 3×10^{-4} *M* mustard gas, which is a specific inhibitor of the deoxyribonucleic acid synthesis[5]. These tests showed (Table 1) that inhibition of synthesis of deoxyribonucleic acid is reflected in a decrease of the soluble-iron fraction.

Statistical analysis showed a consistently high correlation between deoxyribonucleic acid and soluble iron (Table 2); no such correlation was found between deoxyribonucleic acid and either total or insoluble iron. The deoxyribonucleic acid and soluble-iron contents were therefore plotted against one another, irrespective of the treatment employed, and the best-fitting regression lines were calculated for each species according to the formula $y = a + bx + \varepsilon$, where y is soluble iron, x is deoxyribonucleic acid, a is the intercept on the y-axis, b is the calculated slope and ε is experimental error (Table 2).

The a's were found to be not significantly different either from each other or from the origin of the co-ordinates; the regression lines were therefore drawn through the origin and the slopes were calculated accordingly (Fig. 1).

It is seen from Fig. 1 that a change in the amount of deoxyribonucleic acid alters the levels of soluble iron in different species at different rates. Hence one must assume that if the status of iron is indeed determined by deoxyribonucleic acid then its efficiency in doing this differs according to the species in question.

The marked effect of amino-purines upon soluble iron is related to yet another phenomenon, namely,

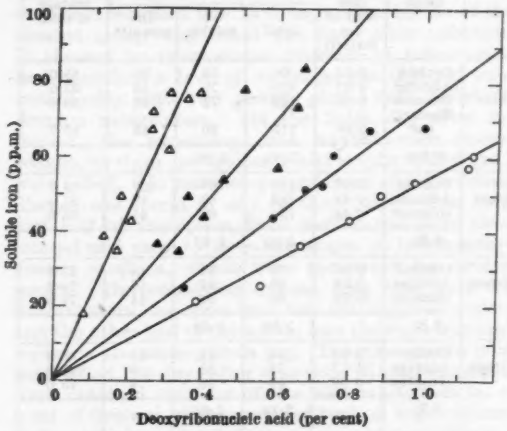

Fig. 1. Relationship between deoxyribonucleic acid and soluble iron in various fruit tree species. △—△, Olive; ▲—▲, plum; ●—●, peach; ○—○, grape

lime-induced chlorosis (lack of chlorophyll), which has frequently been correlated with insufficient iron supply[6–9]. It is assumed by several workers in this field that this phenomenon is not always caused by a total lack of iron, but often by a physiological deficiency of a form of iron which is thought to be active in chlorophyll formation (for example, refs. 3, 7, 9 and recent unpublished results in our laboratory). This fraction was found to be extractable with hydrochloric acid and was called the 'active' fraction[3]. In view of our previous results on the effect of amino-purines upon the soluble (active)-iron fraction, chlorotic grape, peach and plum branches were sprayed with 50 p.p.m. solutions of adenine and guanine, respectively. After three weeks, leaves were collected, extracted with ethanol, and chlorophyll was determined against a bichromate–copper standard[10]. Iron was analysed as previously described. Typical results are summarized in Table 3.

Table 3. Effect of Adenine and Guanine upon the Synthesis of Chlorophyll in Chlorotic Fruit Tree Leaves

Species	Treatment	Iron (p.p.m. of dry matter)		Chlorophyll (per cent of fresh matter)
		Total	Soluble	
Grape	Control	54	17	0·099
	Adenine	55	48	0·224
	Guanine	49	36	0·201
	S.E.	1·46	1·92	0·0018
Peach	Control	67	22	0·085
	Adenine	65	59	0·214
	Guanine	68	61	0·250
	S.E.	2·44	1·84	0·0063
Plum	Control	92	19	0·064
	Adenine	80	66	0·230
	Guanine	85	58	0·180
	S.E.	3·38	2·45	0·0038

It is seen that adenine and guanine sprays increased both the soluble-iron fraction and the chlorophyll content of the leaves, whereas the total iron remained again fairly constant. The question therefore remains whether the deficiency of total iron is the causal factor in all cases of lime-induced chlorosis, even if the supply of iron to chlorotic plants can control this type of chlorosis[6,7,11]. Our results would seem to indicate that in lime-induced chlorosis a disturbance of the deoxyribonucleic acid metabolism is involved, reducing the physiological availability of iron, and thus leading finally to chlorosis.

Considering in this latter respect once again (Fig. 1), it is of interest to note that the divergence of the regression lines corresponds fairly well with the well-known characteristic inherent resistance of the various species to lime-induced chlorosis, olive trees being far more resistant than grape vines.

My thanks are due to Dr. J. Putter for the statistical analysis.

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LETTERS TO THE EDITORS

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Polyphenoloxidase ('Tyrosinase'): Purification and Molecular Properties

POLYPHENOLOXIDASE has been prepared from potatoes by Kubowitz[1] and from cultivated mushrooms (*Psalliota campestris*) by Keilin and Mann[2]. The degree of purification attained was certainly very high, and it is conceivable that the enzyme was obtained in a pure or near pure state. However, the yield of these preparations was very low: 0·3 per cent and 3 per cent respectively. This, and the inadequacies and the difficulties of the methods available in 1938, did not permit verification of the homogeneity of these preparations and the study of the molecular properties of the enzyme. Ten years later, polyphenoloxidase was prepared from mushrooms by Dawson *et al.*[3]. Their preparation, apparently homogeneous electrophoretically, was found to be polydisperse in the ultracentrifuge[4]. So far as we know, despite the considerable interest in the enzyme[5], no other large-scale preparations have since been reported.

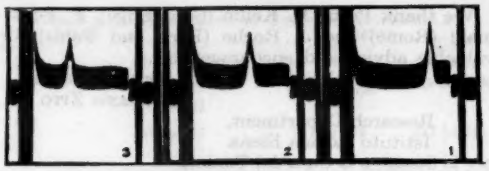

Fig. 1. Sedimentation pattern of polyphenoloxidase. The solution contains 13·3 mgm./ml. enzyme in 0·005 *M* disodium hydrogen phosphate. Rotor speed, 59,780. *T*, 20° C. Exposures at (1) 31, (2) 63 and (3) 95 min.

Indeed, the purification of the polyphenoloxidase is a difficult task. Some of these difficulties are common to the isolation of the respiratory enzymes in general. Additional difficulties are the great inhomogeneity of the best starting material (mushrooms), which make it difficult to devise a thoroughly reproducible method of purification and, above all, the extraordinarily rapid formation of coloured oxidation products during the first stages of purification. As the elimination of these oxidation products, once they are formed, entails very heavy losses, this last difficulty requires special precautions and rapid work.

Our purification procedure, from 120 kgm. of mushrooms, is summarized in Table 1. Details will be reported elsewhere. Here it must be pointed out that to keep the formation of coloured oxidation products as low as possible, steps 1 and 2 of the procedure (dehydration and homogenization of the frozen mushrooms in acetone at − 20° C.; extraction with 30 per cent acetone in closed centrifuge tubes; rapid precipitation, tube by tube, of the supernatant with 1·5 vol. acetone and dissolution of the precipitate) must be completed during one working day. As it was impossible, using two refrigerated centrifuges of the International type, to process more than 3 kgm. of mushrooms during this period of time, five similar preparations were pooled, frozen and afterwards worked up together through steps 3, 4, 5 and 6. Two such preparations (each one corresponding to 15 kgm. of mushrooms), always pooled frozen, were worked up together through steps 7 and 8. In the last steps of the procedure, four preparations (each one corresponding to 30 kgm. of mushrooms) were combined.

It may be pointed out that the first extract in 30 per cent acetone constitutes an essential phase of the purification. A water extract, as used in other methods[1-3], would contain only 2·40–0·60 enzymatic units per 1 mgm. dry weight of non-dialysable matter.

Table 1. PREPARATION OF POLYPHENOLOXIDASE FROM 120 KGM. OF MUSHROOMS

	Volume (ml.)	Concentration (units/ml.)	Content (units × 10^{-3})	Dry weight (mgm./ml.)	Specific activity (units/mgm.)	Yield Partial (per cent)	Yield Total (per cent)
(1) 30 per cent acetone (supernatant)	197,559	175	35,000	4·1	42·5		
(2) 1·5 vol. acetone (precipitate)	33,880	1,100	38,300	14·5	76		
(3) Calcium acetate (I) (supernatant)	35,550	998	35,000	7·6	130		
(4) Calcium acetate (II) (supernatant)	36,340	810	29,400	3·1	270	84	
(5) 46° C. (supernatant)	35,335	785	27,700	2·2	356	94	79
(6) 45 per cent acetone (precipitate)	5,070	4,200	21,250	8·5	496	68	62
(7) Ammon. sulphate, 0·45 sat. (precipitate)	760	23,400	17,800	17·9	1,305	83	51
(8) Alcohol–acetone–sodium acetate (precipitate)	910	19,700	18,000	12·3	1,600	100	51
(9) Ammon. sulphate, 0·46–0·48 sat. (precipitate)	192	47,400	9,100	13·7	3,430	46	26
(10) Ammon. sulphate, 0·425–0·462 sat. (precipitate)	95	66,300	6,300	11	5,700	69	18
(11) Acetone–calcium acetate (precipitate)	48	90,900	4,360	13·3	6,850	69	12·5

The final preparation was found to be electrophoretically homogeneous (phosphate buffer 0·05 *M*; *p*H = 7·06). In the ultracentrifuge the sedimentation pattern shows only one single sharp and symmetrical peak (Fig. 1). The enzyme is pale yellow in colour; the absorption spectrum shows a sharp and intense band at 283 mμ (E (1 per cent, 1 cm.) = 27·55) and a just perceptible shoulder at 340 mμ, but no other specific bands are visible. The copper content of the enzyme is 0·20 per cent. The sedimentation constant extrapolated to zero concentration is $S_{20} = 2{\cdot}7 \times 10^{-13}$ sec., and the diffusion constant is $D_{20} = 7{\cdot}7 \times 10^{-7}$ cm.^{2} sec.$^{-1}$. The partial specific volume is $V = 0{\cdot}758$ cm.^{3} gm.$^{-1}$. The molecular weight of the enzyme is consequently about 34,500, which is a value in good agreement with the minimum molecular weight calculated (31,500) on the basis of the copper content.

We thank Profs. D. Keilin (Cambridge), F. Pentimalli (Rome) and J. Roche (Paris and Tunis) for valuable advice and encouragement.

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Influence of Traces of Heavy Metals on the Reaction Velocity and Turnover of Yeast Alcohol Dehydrogenase

Vallee and Hoch reported in 1955 that yeast alcohol dehydrogenase is a zinc-containing enzyme and that *o*-phenanthroline inhibits its activity by formation of an inactive *o*-phenanthroline–zinc-protein complex[1,2].

In our studies on antigenic properties of yeast alcohol dehydrogenase and the kinetics of the antigen–antibody reaction, it was found that whereas higher concentrations of *o*-phenanthroline inhibit the activity of the yeast alcohol dehydrogenase, lower ones actually increase the rate of reaction. Fig. 1 shows the influence of *o*-phenanthroline upon the reaction-rate, studied by the spectrophotometric technique of Warburg[3], in a test system in which the usual reagents of analytical grade were used and prepared in a double glass-distilled water. Alcohol was used as a substrate, and the semicarbazide as an aldehyde binder.

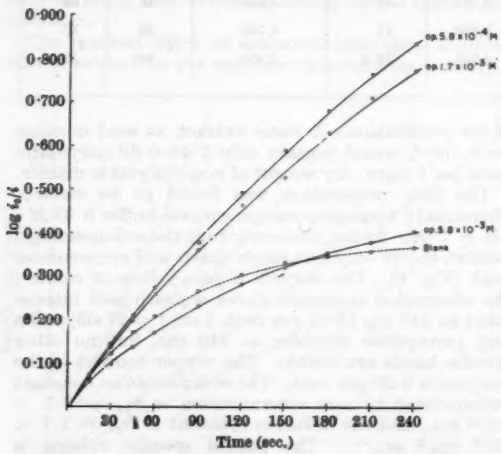

Fig. 1. Action of *o*-phenanthroline on the reaction-rate of alcohol dehydrogenase in a test system containing traces of heavy metals (as present in the usual analytical grade reagents). Phosphate buffer 0·064 *M*, semicarbazide 0·015 *M*, alcohol 0·32 *M*, diphosphopyridine nucleotide $1·8 \times 10^{-3}$ *M*. Enzyme added at zero time, and readings taken every 15 sec., wave-length 340 mμ, Δ *d* = 1 cm., blank without *o*-phenanthroline, *p*H 7·38

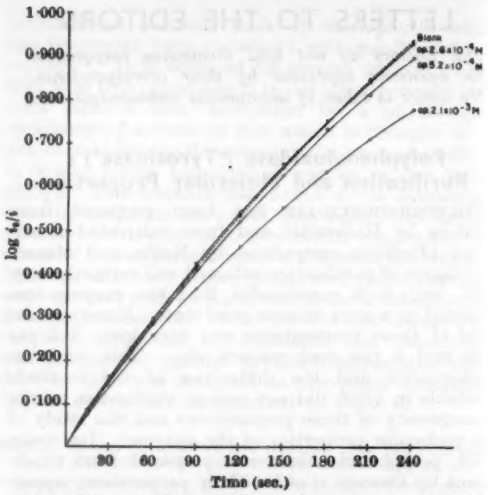

Fig. 2. Action of *o*-phenanthroline on the reaction-rate of alcohol dehydrogenase in a highly purified test system. Phosphate buffer, semicarbazide, alcohol and diphosphopyridine nucleotide, same concentrations as in Fig. 1, *o*-phenanthroline $2·6 \times 10^{-4}$ to $2·1 \times 10^{-3}$ *M*, *p*H 7·46

The rate of reaction is increased by low concentrations of *o*-phenanthroline ($5·8 \times 10^{-4}$ *M* and $1·7 \times 10^{-3}$ *M*). The curve for the blank without *o*-phenanthroline differs in two respects from those with it present in various concentrations: (1) the initial velocity is lower, and (2) the degree of inactivation with increasing time is greater. The crossing of the blank curve with that for $5·8 \times 10^{-3}$ *M* *o*-phenanthroline indicates that at this concentration the initial velocity is reduced by the formation of an *o*-phenanthroline–enzyme complex. During the course of the reaction, however, the rate of such inhibition is decreased. The degree of activation is directly related to the diphosphopyridine nucleotide concentration: a rise in concentration of diphosphopyridine nucleotide leads to a greater percentage activation when the concentration of *o*-phenanthroline is constant.

This influence of low concentrations of *o*-phenanthroline might be explained by the concomitant binding of traces of heavy metals present in the test system and which progressively reduce the enzymatic activity. In order to test this possibility, double-distilled water was purified by shaking with 'Dithizon'-chloroform and redistilled after addition of 50 mgm. of *o*-phenanthroline/litre water. The conductivity did not exceed 1×10^{-6}. The buffer salts and semicarbazide were recrystallized once or twice from hot water; the alcohol and hydrochloric acid were redistilled. The diphosphopyridine nucleotide used was 96 per cent pure (spectrophotometric assay). The twice-crystallized enzyme (obtained from Worthington Biochemical Corp.) was further recrystallized twice from an ammonium sulphate solution; only the first crystalline fraction precipitating was used. This was resuspended in 0·4 saturated ammonium sulphate solution.

Fig. 2 shows the activity of alcohol dehydrogenase in a medium almost free from metals: the rate of reaction in the control is much higher than that in the medium commonly used (Fig. 1). The addition of *o*-phenanthroline does not increase the activity of the enzyme further, but begins to show an inhibitory

effect. The increase in activity is only apparent; actually it is produced by the removal of heavy-metal ions. The lower affinity of the zinc-enzyme protein for *o*-phenanthroline as compared with that of the free ionized metals[3,4] explains why low concentrations of *o*-phenanthroline have an activating effect in the presence of heavy metals and an inhibitory one when the amount of heavy metals is reduced to a minimum. The increased activation of the enzyme with increasing concentrations of diphosphopyridine nucleotide can be interpreted by the competitive action of *o*-phenanthroline and the nucleotide on the zinc bond of the enzyme molecule[3].

In face of this evidence, the conclusion was drawn that the existing turnover number of alcohol dehydrogenase may be too low if estimated in a test medium containing traces of metals. Therefore we decided to estimate the turnover number in the purified test medium.

For the estimation of the maximal reaction velocity the enzyme was diluted in ice-cold pyrophosphate buffer (0·05 *M*, *p*H 7·4) and the reaction was started by the addition of an aliquot. The final concentrations were: phosphate buffer 0·065 *M*, semicarbazide 0·014 *M*, alcohol 0·49 *M*, diphosphopyridine nucleotide $2{\cdot}5 \times 10^{-3}$ *M*, enzyme 0·51 μgm. protein/ml., *p*H of the reaction 7·91, temperature 20° C. The increase in optical density at 340 mμ for the first 15 sec. was taken as the maximal reaction-rate under the conditions described (E_m for diphosphopyridine nucleotide: $6{\cdot}22 \times 10^6$). The calculated turnover number showed that one molecule of alcohol dehydrogenase (molecular weight 150,000) reacts with 42,900 molecules of alcohol per minute. The turnover numbers given by previous investigators are: Negelein and Wulf[5] 36,300 (*p*H 7·9, 20° C., recalculated for a molecular weight of 150,000) and Hayes and Velick[6] 26,800 (*p*H 7·9, 26° C.).

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Visible Absorption Spectra of Commercial Preparations of Cytochrome c

Max Møller and Prescott[1] have directed attention to a series of previously unrecorded absorption bands of reduced solutions of cytochrome *c* from heart muscle (Sigma Chemical Co., U.S.A.; and Boehringer und Sohne, Mannheim). In the course of an investigation of the cytochrome occurring in fungi, we have examined several commercial preparations of cytochrome *c* for purposes of comparison (Sigma Chemical Co.; L. Light and Co.; etc.); the results obtained with Sigma and Light's materials are recorded in Table 1.

Table 1. Visible Absorption Bands of Reduced Cytochrome c*

Sigma		Light's	
− 196°	+ 20°	− 196°	+ 20°
507–*509*–512	*509* to *511*	508–*509*–515	*509* to *511*
516–*520*–*523*–*528*–530	519–*522* to *524*–529	516–*521*–525 526–*529*–530	518–*522*–530
539	*540* to *541*	*540*	
547 to *548*	*547* to *555*	*547* to *554*	*547* to *555*
549–*551*–554			

* Approximate positions of absorption maxima in italic. Hyphens represent regions of diffuse absorption.

For this investigation cytochrome was dissolved in a solution of 7 parts (v/v) glycerol and 3 parts (v/v) 0·1 *M*-phosphate buffer (*p*H 7·2). These solutions were either reduced with a slight excess of sodium dithionite or oxidized with slight excess of potassium ferricyanide. They were examined at room temperature and at −196° using a Zeiss hand spectroscope mounted on an optical bench.

Cooling the cytochrome solutions to the temperature of liquid nitrogen resulted in the absorption bands appearing sharper, but their positions were displaced 1–2 mμ towards the blue end of the spectrum. On warming to room temperature, 70 per cent (v/v) glycerol solutions did not devitrify; solutions of this concentration of glycerol were found, however, to be optimal for observations. If cytochrome solutions in 45–50 per cent (v/v) glycerol were used, devitrification occurred on warming from −196° and this was accompanied by intensification of the bands[2]. It was important to allow the frozen sample to warm up slowly for devitrification to occur. On oxidation, the bands became diffuse at 562–568 mμ and 525–535 mμ. Examination of cytochrome solutions in the 'Unicam S.P. 500' spectrophotometer gave two major absorption maxima at 550 mμ and 520 mμ with small 'bulges' on the sides of these two peaks corresponding to the other absorption bands seen with the direct-vision spectroscope.

The results are in general agreement with those of Max Møller and Prescott, except that we did not observe a band at 500 mμ.

Cytochrome solutions were very stable when left for long periods at room temperature, although in some very old preparations a diffuse band was observed at 585–595 mμ in addition to the bands recorded in Table 1. The solutions oxidized on standing.

Cytochrome *c* preparations made from animal heart by the method of Keilin and Hartree[3] and also preparations of yeast cytochrome *c* made by extracting yeast with 10 per cent (w/v) ammonium sulphate showed the same absorption bands as the commercial preparations when examined at room temperature with the Zeiss spectroscope.

Margoliash[4] has reported the presence of 'modified cytochrome *c*' to the extent of 10–25 per cent in Keilin and Hartree cytochrome *c* preparations. In two fractions isolated on ion-exchange columns he could detect no difference spectroscopically. Henderson and Rawlinson[5] have noted, in addition to the modified cytochrome *c* of Margoliash, an impurity containing hæm. Preparations with varying amounts of this impurity showed little difference in absorption curves in the region 500–560 mμ; but increase in the percentage of hæm impurity gave a corresponding increase in the absorption from 560 mμ towards the red end of the spectrum with maximum effect at 590 mμ. Thus although the presence of hæm compounds other than cytochrome *c* have been recorded in the Keilin and Hartree preparation, a complete interpretation of the spectroscopic observations presented here cannot be attempted at present.

Since this communication was prepared, an important paper on the subject by R. W. Estabrook has appeared[6].

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Immunobiological Studies on Crystalline Alcohol Dehydrogenases from Closely Related Yeast Species

Hitherto, there have been few reports on comparative immunological studies on functionally homologous enzymes from closely related species of microorganisms. Detailed immunobiological and immunochemical studies of this kind have been carried out only upon lecithinases from *Clostridia*[1-3].

We have been studying the immunobiological and immunochemical properties of crystalline alcohol dehydrogenase isolated from two subspecies of *Saccharomyces cerevisiae* (bakers' yeast and brewers' yeast) by the methods of Racker[4] and Keleti[5]. The enzymes from both species acted as antigens on rabbits.

The rabbits were given 260 mgm. alcohol dehydrogenase from brewers' yeast or 130 mgm. alcohol dehydrogenase from bakers' yeast intravenously. The undiluted immune sera were found to have 0·484 mgm./ml. and 1·704 mgm./ml. of the respective antibodies. The enzyme from both species proved to be immunologically homogeneous, since the neutralization zones determined in our precipitation systems had sharp limits.

In our work we first determined the optimal proportions by the dilution method and then we studied the quantitative relationships following Heidelberger and Kendall[6], using the spectrophotometric method of Gittlin[7].

We found that both antigens mutually absorb completely the homologous as well as the heterologous antiserum. The quantities of antigen needed for absorption and the quantities of antibody precipitated by the different antigens are different for the alcohol dehydrogenases isolated from the two species.

The differences between enzymes found by immunological studies is supported by mutual dissolution studies following Landsteiner and Heidelberger[8].

We found that the anti-enzyme-containing serum inhibits the activity of alcohol dehydrogenase from both species. At maximal (100 per cent) inhibition, the ratio of enzyme-antigen to antibody agrees with the ratio of antigen to antibody found at the neutralization point determined in our precipitation systems.

Inhibition becomes total two minutes after the addition of immune serum. This period remains unchanged if the enzyme is pre-incubated with diphosphopyridine nucleotide, or with its substrate previously to the addition of immune serum. However, if the immune serum is added to a functioning enzyme (that is, to antigen which has been previously mixed with diphosphopyridine nucleotide and substrate) the inhibitory action of antibody is delayed. Total inhibition then develops after 20 min. instead of 2 min.

The inhibitory action of antibody does not compete with substrate.

A detailed account of these experiments will be published in *Acta Physiologica Hungarica*.

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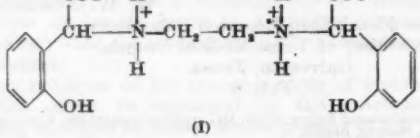
Chelating Tendencies of N,N′-Ethylene*bis*-[2-(o-Hydroxyphenyl)] Glycine

Recent investigations of a wide variety of chelate compounds as carriers of ferric ions in plant nutrition showed the ferric chelate of N,N′-ethylene*bis*-[2-(*o*-hydroxyphenyl)] glycine to be a very effective iron carrier in biological systems. Because of the remarkable properties of this new chelating agent, investigation of its affinity for ferric ions and other metal ions seemed desirable. The structure of this substance (I) differs from that of most of the common ferric ion sequestering agents in that the hydroxyl groups are phenolic rather than aliphatic in nature.



(I)

The acid dissociation constants and chelate stability constants, as determined from the potentiometric titration curves in Fig. 1, are listed in Table 1. The second, third and fourth overlapping dissociations of N,N′-ethylene*bis*-[2-(*o*-hydroxyphenyl)] glycine were calculated graphically by the method of Schwarzenbach and Ackermann[1]. The stability constants were calculated by a conventional algebraic method, except for those for calcium and magnesium

Table 1. Acid Dissociation Constants and Chelate Formation Constants of (I)

Metal	pK_1	Equilibrium constants* pK_2	pK_3	pK_4
H^+	6·32	8·64	10·24	11·68
	log $K(MH_2A)$	pK_a	pK_b	
Cu(II)	>15	4·98	8·04	
Ni(II)	11·40	6·03	7·63	
Zn(II)	9·26	6·04	7·74	
Cd(II)	7·77	7·86	8·70	
	log $K(MH_2A)$	log $K(MHA)$	log $K(MA)$	
Ca(II)	1·6	3·5	6·1	
Mg(II)	2·3	4·6	7·6	

* pK's refer to dissociation constants; K_s values are formation constants for metal complex X.

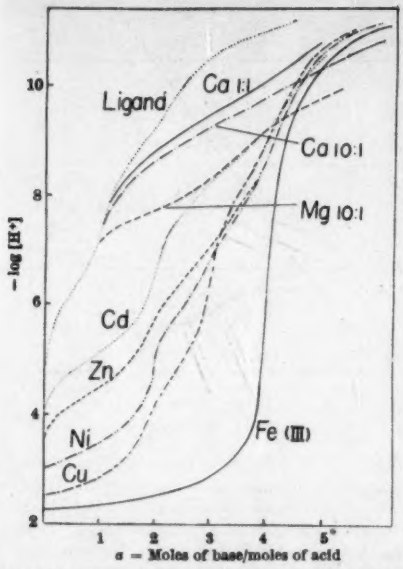
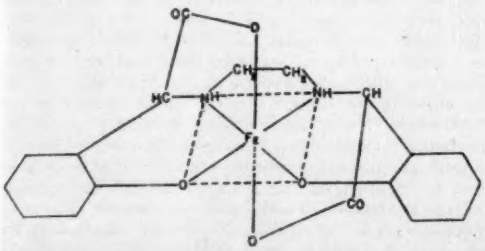


Fig. 1. Potentiometric titration curves of N,N′-ethylene*bis*-[2-(*o*-hydroxyphenyl)] glycine

ions, which were obtained by treating the 10 : 1 metal excess curves in Fig. 1 as two separate dissociation steps at a constant concentration of metal ion.

The titration curves indicate that the cupric, nickel, zinc and cadmium ions first combine with the ethylenediaminediacetate groupings. The subsequent dissociations of these complexes at higher *p*H is probably accompanied by simultaneous rearrangement of the ligand to allow participation of the phenolate groups in chelation. This interpretation is supported by the shift of the ultra-violet band of the cupric chelate from 277 mμ, typical of the acid phenol band, to 285 mμ (compared to 296 mμ for the tetrasodium salt).

The ferric chelate is unique in several respects. The titration curve shows the formation of only a single chelate compound at low *p*H, indicating high stability (log $K > 10^{27}$). The neutralization of four moles of base per mole of ligand indicates participation of both phenolate groups in chelate formation to form a compound having the structure represented by (II). This is confirmed by the existence of a single phenolate absorption band at 282 mμ ($\varepsilon = 5{,}000$) unaffected by *p*H changes from 3 to 11. Potentiometric titration of ferrous ions in a reducing atmosphere in the presence of N,N′-ethylene*bis*-[2-(*o*-hydroxyphenyl)] glycine resulted in rapid oxidation of the metal to give the ferric chelate. Similar oxidation reactions were observed for the cobalt and manganese chelates.



(II)

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Effect of 'Free Space' in the Decomposition of Solid Nitrates by X-rays

We have measured G values for the decomposition of a number of anhydrous nitrates by X-rays of 44·5 kVp. from a beryllium-windowed tube. The decomposition proceeds almost entirely according to the overall reaction:

$$NO_3^- \rightarrow NO_2^- + \tfrac{1}{2}O_2$$

In Fig. 1, G values for the initial rate of decomposition are plotted against 'free space' per nitrate ion in the crystals. The 'free space' is the difference between the volume of the crystal and the volume of the ions in it, taking the volume of the nitrate ion somewhat arbitrarily as 14·5 A.³. (This is the total volume of its three oxygen atoms[1].)

The graph shows an unmistakable correlation between G and 'free space'. This indicates that the tightness or looseness of the 'cage' of surrounding ions is an important factor determining the relative chances of an excited nitrate ion breaking up chemically or reverting to the ground-state undecomposed.

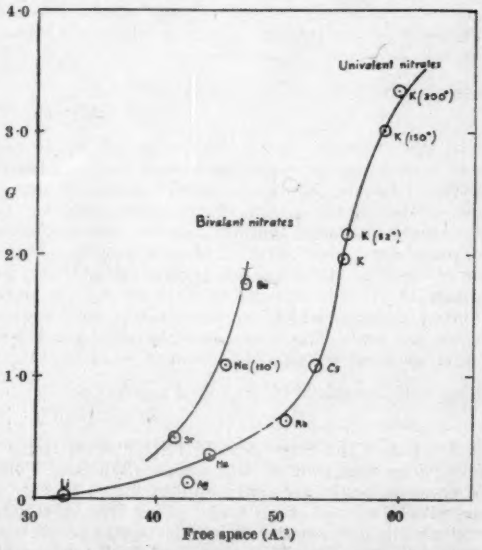

Fig. 1. The number of nitrite ions formed per 100 eV. absorbed (G) as a function of 'free space' per nitrate ion. Temperatures 15–17° C. except where otherwise indicated

The increase in G for potassium nitrate above room temperature can be well correlated with the increase in 'free space' resulting from thermal expansion (see graph). However, G for sodium nitrate increases with temperature out of all proportion to the increase in 'free space': we do not know why.

A full account of this work, and of many other results from the irradiation of nitrates, is being prepared for publication.

The idea that the 'free space' difference might explain the difference between the rates of decomposition of potassium and sodium in a nuclear reactor was first put forward by Hennig, Lees and Matheson[2].

The work described here was carried out at the Queen's University of Belfast, under contract with the United Kingdom Atomic Energy Authority.

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Esterification by the Nitronium Ion in Aqueous Perchloric Acid

The nitronium ion, NO_2^+, has been shown to be the active nitrating entity in the O-nitration of certain alcohols in organic solvents[1] in which nitric acid is present in large excess. Kinetic studies in progress on the esterification of *iso*amyl alcohol with nitric acid in 55–62 per cent aqueous perchloric acid have now indicated that here also O-nitration proceeds through the nitronium ion, although only a very small fraction of the nitric acid can be present in this cationic form in media of such high water-content. Rate measurements at 25° C. made by ultra-violet spectrometric analysis of the unchanged nitric acid after dilution of aliquots with water and extraction of the *iso*amyl nitrate product show that the rate equation (1) is obeyed:

$$\mathrm{d}[iso\text{-AmNO}_3]/\mathrm{d}t = k[iso\text{-AmOH}]\,[\mathrm{HNO}_3] - k'[iso\text{-AmNO}_3] \quad (1)$$

In the range of media studied, about 30–55 per cent conversion to the nitrate ester occurs. Interaction of the medium with *iso*amyl alcohol is negligible. The identification of the nitronium ion as the esterifying agent follows from the demonstration of parallelism over a range of media of log k and log R where R is the ionization ratio $[R^+]/[ROH]$ for a base ROH which ionizes to form R^+ by the same process as that which converts nitric acid to the nitronium ion[3]. The relationship between log k and log R has been tested in the form of equation (2):

$$\text{d log } k/\text{d percentage } \mathrm{HClO_4} = \text{d log } R/\text{d percentage } \mathrm{HClO_4} \quad (2)$$

in which R is the ratio $[NO^+]/[HNO_3]$ for the ionization of nitrous acid to the nitrosonium ion, NO^+, in aqueous perchloric acid[3], and as shown in Fig. 1, the rate of change of log k and of log $[NO^+]/[HNO_3]$ with the medium are the same. The lack of parallelism of log k with the Hammett acidity function[4] H_0 indicates that the esterifying agent is unlikely to be the nitracidium ion $H_2NO_3^+$.

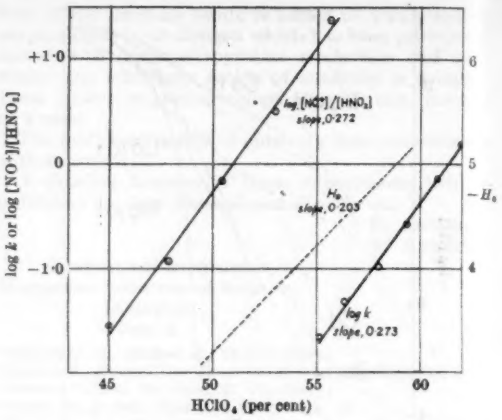

Fig. 1

Equation 2 in its appropriate form was first used for aqueous sulphuric acid media[5] to verify that nitration of aromatic compounds proceeds through the nitronium ion over a wide range of media; R values used were those for the ionization ratio for a triphenylcarbinol indicator, and appreciable deviations were found from equation 2 in certain ranges. We have found that log R for 4-trimethylammonium triphenylcarbinyl methyl ether perchlorate plotted over the range 50–60 per cent perchloric acid gives a straight line of slope of 3·04, which is 10 per cent higher than those for the esterification rate and the $[NO^+]/[HNO_3]$ ratio given in Fig. 1. This suggests that correlations between rate and ionization ratio are dependent on the size of the molecules and ions concerned.

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A Photon Counter of High Sensitivity for the Vacuum Ultra-violet Region

Photo-emissive receivers for the region of the spectrum below 2000 A. have generally used for the sensitive surface pure metals (platinum, tungsten, copper) or alloys (beryllium–copper[1], chrome–iron[2]) the photo-thresholds of which lie near 2000 A., thus rendering them insensitive to stray light in the near ultra-violet. Such materials, while lending themselves to reproducibility of surface, have not shown high quantum efficiencies except at the very short wavelengths[3]—below 1000 A. In the measurement of low light-levels, for which purpose counting of photo-electrons, whether by electron multiplier or gas amplification, is best suited, quantum efficiency may best be defined as the fraction of incident quanta detected, that is, which cause emission of one or more electrons detectable as a group. Values of the efficiency defined in terms of the average number of electrons per incident quantum, which may be rather

higher, have generally been found to range from about 10^{-3} (for beryllium–copper) to only 10^{-7} (for chrome–iron) at 2000 A.

The use of copper iodide as the photo-emissive surface in a photon counter using gas amplification has been described by Lormeau[4], who claimed very high sensitivity for the device though without giving an estimate of its quantum efficiency. However, under the conditions of operation in this case (using alcohol vapour and, in particular, a very low external resistance) the response to variation of light intensity was markedly non-linear. It may be inferred that a large instantaneous current was passed by the counter and that non-linear behaviour was the result of both excessive internal photon production and polarization of the semiconducting layer of copper iodide.

It has now been found that strictly linear response over a range of not less than 10^3 can be obtained with this surface if counter operation is confined to the proportional region (cf. Curran, Cockroft and Augers[5]), and that the use of fluorite window and methane filling (12 mm. pressure) results in sensitivity to radiation in the vacuum ultra-violet.

The photocathode was prepared by treatment of clean copper foil with a dilute solution of iodine in carbon tetrachloride to form a thin adherent layer of iodide which was washed several times with boiling carbon tetrachloride to free it from excess iodine. The long wave-length threshold has been confirmed at near 2300 A. and sensitivity found to increase rapidly until about 2000 A. is reached. Between 2000 A. and the transmission limit of the fluorite spectrograph (1450 A.) used in this investigation no marked change in sensitivity was apparent.

The quantum efficiency in the region 1850–2150 A. has been estimated from the count-rate observed with the counter exposed (at 10 cm. distance in air) to radiation from a heated platinum strip, the temperature of which could be determined by optical pyrometer. The remarkable value of between 10^{-2} and unity is supported by the observation that replacement of the copper iodide coated cathode by one of etched copper (quantum efficiency at 2000 A. *c.* 10^{-4}) caused the count-rate to fall by a factor of at least 10^2.

Such high sensitivity and linearity of response make this device a useful receiver for spectroscopic studies in the 1000–2000 A. region. The use of this counter in a double-beam vacuum spectrometer in these laboratories has enabled measurements of absorption intensities to be made, the accuracy of which was limited only by ratemeter linearity and statistical counting errors. It has been observed that the cut-off at 2300 A. renders the effect of scattered light (derived principally from the longer wave-length emission of the hydrogen discharge tube) quite negligible in the region studied. It is hoped to publish details of the construction of the counter, spectrometer and associated apparatus elsewhere with reports of spectroscopic studies

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Arc Movement and Electrode Magnetism

Recent experiments on arcs in free air have shown that the presence of magnetic fields in the surface of the electrodes greatly influences the arc movement.

In these experiments, two cylindrical electrodes 1 cm. in diameter were mounted horizontally and parallel with their axes in a vertical plane and 3·2 cm. apart, the anode being uppermost. The electrodes were connected at one end to a source of current, the other end being free, and the arc was initiated at the current-feed end by exploding a wire. The arc was photographed as it travelled towards the free end of the electrode system under the action of the magnetic field due to current in the electrodes. The camera was of the rotating-drum type operating at 960 frames per sec.

For arc currents up to about 400 amp., regular and continuous tracks were found on the cathode, but regular tracks on the anode occurred much less frequently for all the electrode materials tested. The cathode-spot velocity was found to increase uniformly with arc current, being the same for copper, aluminium and brass, but much greater for mild steel and stainless steel, which are magnetic.

The hypothesis that the higher velocities with the ferrous electrodes are due to their magnetic properties was tested by magnetizing the electrodes in the axial direction. It was found then that the cathode spot followed a helical path; in some cases completing three revolutions of the cathode. If the direction of magnetization was reversed, the helix direction was also reversed. Since the sense of the helix was the same whether the cathode was magnetized as an electromagnet or as a permanent magnet, although the field in the air away from the cathode surface was reversed by this procedure, it was concluded that the circumferential motion was determined by the axial magnetic field *within* the cathode surface. When the axial field was absent, a circumferential field still existed within the electrode, being caused by the current flow, so that it was important to establish whether or not this field influenced the axial motion of the arc towards the free end of the electrodes.

Two pieces of evidence suggest that this internal circumferential field had great influence: (1) the velocity was much greater on ferromagnetic cathodes, as already mentioned; if the internal field is important, an increased velocity would be expected since the circumferential field would be concentrated within a magnetic cathode; (2) further evidence has been found by comparing the axial and circumferential velocities of the helix motion with the corresponding internal circumferential and axial magnetic fields. For a given arc current, the resulting circumferential flux density in the metal at the electrode surface was calculated. Then from curves relating circumferential velocity to arc current and axial flux density, a value of circumferential velocity was found for the same arc current, and for an axial flux density corresponding to the calculated circumferential value. The circumferential velocities found in this way were in close agreement with the axial velocities for the same arc currents, and indicated that both velocities were induced by similar internal magnetic fields.

Helical motion of the anode spot was also found when the anode was magnetized axially, but the

movement was in an opposite sense to that on the cathode. Tests with electromagnetic or permanent magnetic anodes again showed that the internal field was responsible.

The results show that movements of the arc spots are caused by local, surface magnetic fields, which are in the same direction as the fields in the bulk metal.

It is suggested that transverse galvanomagnetic and thermomagnetic forces[1] are responsible for the motions observed, acting within the cathode and anode spots. On the cathode, such effects could modify the pattern of electron emission and so determine the new sites to which the cathode spot might move. These forces have been discussed by Ware[2] and by Smith[3] in connexion with retrograde motion of mercury-arc cathode spots at reduced pressures. In the present case we have to consider these effects within the solid–liquid–vapour transition region of the cathode spot, where the electron density and density gradients, as well as thermal gradients, are much greater than in the regions of the discharge away from the micro-surface of the cathode. Although Ware[2] concluded that thermomagnetic effects will rarely be important in laboratory discharges, it would seem that, within the micro-regions considered here, thermomagnetic as well as galvanomagnetic forces should be considered.

On the anode, the galvanomagnetic forces appear to be reversed with respect to the thermomagnetic ones; but until more is known about anode mechanisms, it is not possible to be certain that this reversal accounts for the reversed helix motion on that electrode.

It is hoped that a more detailed account of this investigation will be published elsewhere. The work arose out of an investigation on arcing devices for the British Electrical and Allied Industries Research Association, to which thanks are due for the use of the camera. One of us (T. J. Lewis) acknowledges the award of a Turner and Newall Fellowship by the University of London.

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A High-Intensity Light Source for Stroboscopic Operation at Frequencies up to 250 kc./s.

We have constructed a high-voltage cathode ray tube in which the beam excites the entire screen surface simultaneously and uniformly; the peak beam-current may exceed 100 m.amp. for short periods without damage either to the cathode or the phosphor. The intensity and duration of the electron beam-pulse are controlled by the grid, complete cut-off being possible without removal of the anode voltage. By a suitable choice of screen phosphor (a zinc oxide supplied by Messrs. Levy-West) the form

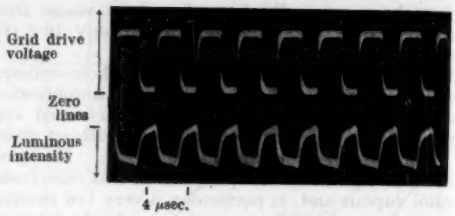

Fig. 1. (*a*) Oscillogram of a 250-kc./s. square-wave voltage pulse applied to control the flash tube. (*b*) Oscillogram of the corresponding light pulses

of the light pulses may be made to follow that of the control signal up to frequencies approaching one megacycle per second.

With an accelerator voltage of 20 kV. and square-wave beam-current pulses of 100 m.amp. the peak power dissipated at the screen was 2 kW. and the radiation pulses produced had a peak luminous intensity of about 3,500 candelas normal to the screen with an associated luminous flux of about 10^4 lumens. The screen was 5 cm. in diameter and hence its luminance was nearly 2×10^6 candelas per sq. m.

Fig. 1*a* shows the oscillogram of a 250 kc./s. square-wave voltage pulse applied to drive the control grid of the tube, and Fig. 1*b* represents the corresponding train of current pulses generated by an electron multiplier photocell receiving the light output. The output pulses are substantially the same in shape as the control voltage pulses but show the effects of build-up and decay which are characteristic of the phosphor used. The colour of the radiation was predominantly green. Similar results have been obtained with phosphors radiating ultra-violet and, with the aid of filters, the near infra-red.

We found that the heating of the screen limited the rate of 2-μsec. pulses at 100 m.amp. peak to about 1 kc./s. for continuous operation, but trains of flashes at any rate of repetition were possible for brief periods of less than one second. Continuous operation at high frequencies was possible by reducing the duration of the pulse or the peak beam-current, which, for example, was 400 μamp. in the case of 2-μsec. pulses at 250 kc./s. as in Fig. 1.

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Television Images

It was observed, while watching a television screen from about 6 ft., that, if the eyes were moved rapidly across the screen from a point about one foot to the left of the screen to a point a similar distance to the right, a clear picture could often be seen to the right of the screen. It was in the shape of a parallelogram with base and height the same as the screen, sloping to the right. It appeared almost as bright as the screen, and the picture on it could often be seen in considerable detail. If the eye movement was in the opposite direction, the same effect was obtained, with the parallelogram sloping to the left. By moving the eyes through a wider arc, more than one such image could be seen.

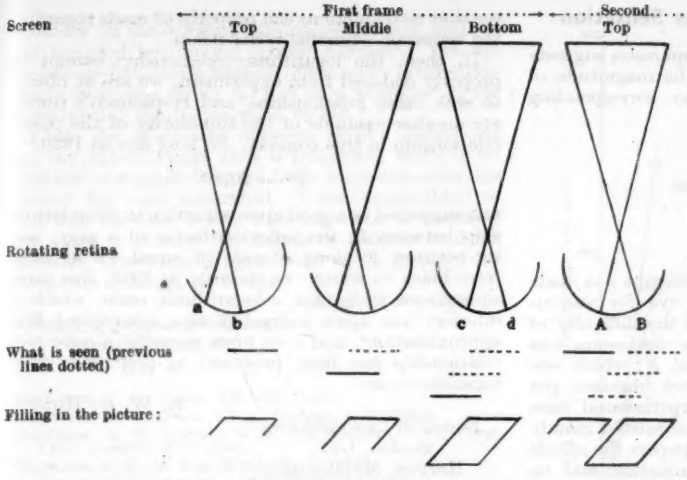

Fig. 1. Mode of representation on the retina during left-to-right eye movement

It was supposed that this was the representation of a single frame of the picture, the slope being due to the movement of the retina during the production of the picture from the top to the bottom. Fig. 1 shows schematically how two successive frames would strike the retina in a left-to-right eye movement. The arc *cd*, representing the bottom of the first frame, is farther to the right on the retina than *ab*, the top, so it is seen more to the left, hence the slope. If the speed of movement is such that the arcs *ab* and *AB* do not overlap at all, the two frames will be seen as separate from each other.

A set of observations was made at increasing distances from the screen, keeping the angle of eye movement constant. This was done by means of two luminous fixation points in the plane of the screen, which, for each viewing distance, were placed at that distance apart at which they subtended an angle of 60° to the eye. Viewing distances were 3, 4, 5, 6, 8 and 10 ft. The screen measured 10½ in. by 8 in. Only left-to-right eye movements are considered. The speed of saccadic eye movements is said to be constant for a given person and a given angle of movement (Woodworth[1]).

Hence it was predicted : first, that the time being equal in each case, the number of images would be the same at all distances ; secondly, that, with increasing distance, the images would be more separated since they would occupy a smaller proportion of the visual arc ; thirdly, that, with increasing distance, the slope of the parallelogram would increase. The time from the top to the bottom of the picture remaining the same, and the speed of rotation of the retina being constant, the bottom of the image would be displaced the same amount along the retina. But since the retinal image at the greater distance would be smaller, the slope would be greater.

In the trials it was found that 3½–4 images were seen at each distance, all to the right of the screen, stretching from the screen to the right-hand fixation point or just beyond it. It was not always possible to count them exactly, as there were sometimes incomplete images at each end.

At 3 ft. the images overlapped by about half their width, at 5 ft. they were almost separate, and at 6 ft. were clearly separated with a space between of about 1/5 of the base of the image. The slope increased from about 75° to the horizontal at 3 ft., to 30° or less at 10 ft.

The three and a half to four frames would take about 75 msec., and this is the right order of time for half the 60° sweep, according to Woodworth[1].

When the four images are seen, none of them is so clear as when one only is seen, in a narrower sweep. It will be seen from Fig. 1 that in the left-to-right movement, each image is farther to the right on the retina than the previous one, and so is seen to the left of it. Thus, when four images are seen, the latest one is that on the left, nearest to the screen ; it is seen with the periphery of the retina, where visual acuity is less good. The one which is seen with the centre of the retina is that on the right near the final fixation point, and this is the oldest and most faded image. The clearest picture is obtained from 6–7 ft. by stopping about a screen's width from the screen, when just one image is seen with central vision.

If the eyes are moved vertically across the screen, in the downward movement a very bright compressed image is seen below the screen ; in the upward movement there is a faint vertically elongated image above the screen. The difference is due to the fact that the picture is always produced from the top, and the reason for the type of distortion in each case can be seen by making a diagram similar to Fig. 1 for vertical movement. In diagonal movement, a combination of the vertical and horizontal distortions is found.

These images, although displaced from their place of origin, are clearly not after-images, but first images, showing after-lag when several are seen at once. Their interest lies in the fact that they afford a unique opportunity of obtaining a clear image in rapid eye movement (although distorted in shape and displaced), due to the peculiar method by which the television picture is formed. If the eyes are moved rapidly across a luminous picture in a dark room, just streaks of light are seen, since each part of the retina is stimulated successively by different parts of the picture. With the cinema, too, there is a blurred effect, because each frame is projected whole for a time on to the screen ; but in the television image the successive points of light which form the picture are so rapid that there is no blurring on the retina even in swift eye movement.

I thank Dr. S. L. Last for directing my attention to these images and discussing them with me ; and also Mr. N. W. Ellis for information on the manner of production of the television picture.

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Light Energy and Brightness Sensation

In his recent communication[1], Hopkinson suggests that the relationship between M, the magnitude of brightness sensations, and L, the corresponding physical luminance, is

$$M = kL^{0.3}$$

for dark-adaptation conditions; and

$$M = kL$$

for light-adaptation conditions.

In a paper published in 1953 [2] an attempt was made to derive response curves for the eye for various states of adaptation, but because of the difficulty of discussing sensation magnitudes the discussion was limited to the physiological response, N, which was thought of as the number of nerve impulses per nerve fibre per unit time. The experimental data upon which the attempt was made consisted mainly of two papers by Craik[3,4]. In these papers the effects of adaptation on luminance discrimination and on apparent brightness were reported, but all the results depended on judgments either of equality of brightness, or of a just noticeable difference in brightness, between two fields. From these results, in the paper cited[2], a self-consistent pattern of physiological response functions was built up and it was concluded that

$$N = kL^{1/3}$$

for dark-adaptation conditions; and

$$N = kL^{p}$$

where p is not less than 1 and not more than 3, for light-adaptation conditions.

The agreement between these results and Hopkinson's is most striking. If both analyses are correct one would conclude that sensation magnitudes are proportional to the number of nerve impulses per nerve fibre per unit time (and not, for example, to the logarithm of that number).

There has for a long time been a tendency to regard the sensation–stimulus relationship in vision as a logarithmic one, and this has arisen mainly from two arguments. First, luminance discrimination results have been integrated and results linear with the logarithm of the stimulus intensity have been obtained. Secondly, changing all the luminances of a scene by the same percentage (as, for example, by viewing it through a neutral filter) does not affect the appearance of the scene appreciably (providing adequate time is allowed for adaptation), whereas adding the same luminance to each part of the scene (as, for example, when the scene is viewed through haze or fog) does affect the appearance of the scene very markedly (even when full adaptation has taken place). However, luminance discrimination results are entirely concerned with just noticeable differences, and there is evidence[2] that these are governed by random variations in the stimuli or in their perception and not by any relationship between sensation and stimulus magnitudes. As for the constancy of appearance of a scene when viewed through a neutral filter, this would occur if, on placing the filter in front of the eye, adaptation occurred in such a way that the photochemical absorptions in the retina were unchanged; with filters of moderate density this is almost sure to be the case, while for very dense filters the appearance of the scene does not in fact remain constant; so that here again we see that no deductions can properly be made regarding the sensation–stimulus relationship.

If, then, the logarithmic relationship cannot be properly deduced from experiment, we are at liberty to seek other relationships, and Hopkinson's results are another example of the superiority of the power relationship in this context. So long ago as 1920 [5]

$$V = kR^{1/3}$$

was suggested as a good approximation to the relationship between R, the reflexion factor of a grey, and its position V along a scale of equal visual steps from black to white. So recently as 1952, this same square-root scale (not a logarithmic scale, which is inferior) was again suggested as a convenient first approximation[6], and even more recently[7] a cube-root relationship has been proposed in preference to a logarithmic one.

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I am encouraged to note that Hunt finds my data on brightness magnitude[1] in broad agreement with his deductions, from a consideration of the neural responses, about the basic sensation–stimulus relations for the eye; but I would not wish to read too much into this agreement. My communication contained only a brief report of these recent brightness-estimate experiments; but I referred to earlier studies made by a method which involved mental estimates of equal, supra-threshold contrasts, and to the broad general agreement but detailed disagreement between these earlier studies[2,3] and the later work. A more detailed exposition is given in another paper[4]. The differences between the sensation–stimulus relations obtained by one method and by another may be important, both theoretically and also in the practice of lighting engineering. They may arise from different experimental conditions; but I cannot avoid the suspicion that there are real differences between the stimulus–contrast relation and the stimulus–brightness relation. Our training leads us to expect that brightness magnitude can be deduced from contrast magnitude, and vice versa, and thence that we can construct a scale of brightness by adding contrasts, either minimal, as Fechner did, or supra-threshold, as I did in my earlier work, just as we can construct a foot-rule by adding inch-intervals one to the other. To a limited extent we can, and this is why these early brightness scales have been so useful in practice. Sooner or later, the employment of these scales leads us into discrepancies, because 'contrast' does not always seem to be the same thing as 'difference of brightness'. Perhaps there is no reason why it should be.

One simple example may suffice. The contrast in a sunlit snowscape or a bright white cloud can be enhanced by looking through a neutral filter of density $D = 0{\cdot}3$–$0{\cdot}7$. This confirms the existence of a

'shoulder' in the contrast–luminance relation, such as was reported by (among others) Abribat[5]. Yet the brightness–luminance relation obtained by direct magnitude estimates shows no sign of a 'shoulder' in the experimental results recorded so far.

While the agreement between Hunt's deductions and my experimental data is satisfying, there is no evidence to suggest that the basic sensation–stimulus relation has been unearthed. I am disappointed to read that Stevens, whose work has done as much as any other to shatter the dogma of Fechner and his followers, now himself appears to claim finality[6] for the power relation $M = kL^{\gamma}$.

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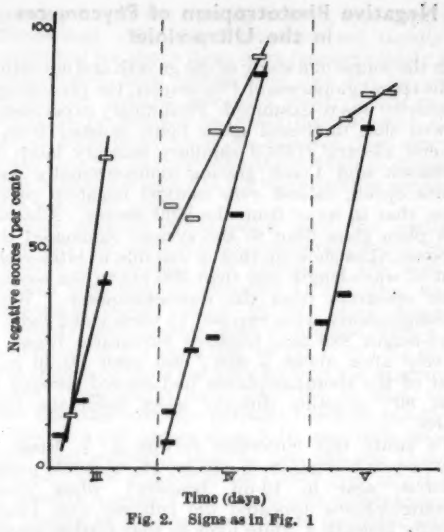

Fig. 2. Signs as in Fig. 1

Changes in Phototaxis during the Larval Life of the Eyed Hawk Moth

In experiments on phototaxis in caterpillars, great variability is often found among the reactions to the same conditions of different individuals, or of the same individual at different times. No satisfactory analysis of the mechanisms underlying the phototaxis will be possible until we know, and can control, the factors governing this variability. The following results show that, at least in the eyed hawk moth (*Smerinthus ocellata* L.), the age of the larva is one important variable which should be more rigidly controlled than is usually done in work on caterpillar phototaxis.

We carried out our experiments in a dark room on a horizontal table, lighted with a 15-W. fluorescent tube (Philips *TL-D* 34 de luxe) mounted horizontally at one edge of the table, and occupying the full length of this edge. Our caterpillars were reared in the laboratory in normal daylight. In each test, four or five larvæ were put on the table at a distance of 45 cm. from the light, and allowed to crawl. As soon as a larva had crawled more than 20 cm. towards or away from the fluorescent tube, it was put back at the starting line. The direction in which each larva was heading was noted at 1-min. intervals, a + or a − being scored for larvæ crawling towards or away from the light, respectively. For larvæ moving at right angles to the direction of the light or nearly so ($90 \pm 22{\cdot}5°$), 0 was scored. The percentage of 0 scores was always rather low (average of all tests, 5·7 per cent). Resting larvæ were excluded from the observations presented here. The total number of scores per test was never smaller than 80, and usually between 100 and 150. We carried out the tests at various stages in the third, fourth and fifth instars, using the same group of larvæ throughout the series. Later, we repeated the whole series on another group of larvæ.

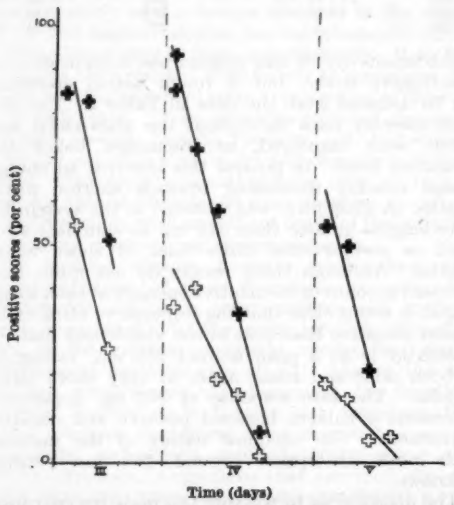

Fig. 1. Roman numerals: instars. Black signs: series 1. Open signs: series 2

The results are summarized in Figs. 1 and 2. In both series of tests, the larvæ are far more often photopositive, and less often photonegative, at the beginning of each *instar* than towards its end. Clearly, reproducible results can be expected from experiments on phototaxis in our species only if the age of the larvæ used is known to the day. Apart from this practical point, the phenomenon described also raises interesting problems both as regards its causation and its functional significance. We are extending the experiments with better methods, and will postpone the discussion of these problems to a later more detailed paper.

As can be seen from the graphs, the larvæ of series 2 were consistently more photonegative than were those of series 1 at a comparable age. This indicates that other, as yet unidentified, factors play a part as well.

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Negative Phototropism of *Phycomyces* in the Ultra-violet

In the course of a study of the growth and curvature of the sporangiophores of *Phycomyces*, the phototropic sensitivity was re-examined. Preliminary experiments showed that unfiltered green light, isolated from a General Electric *H85C3* capillary mercury lamp by a Bausch and Lomb grating monochromator with quartz optics, caused very marked negative curvatures, that is, away from the light source. Addition of a plain glass filter to the system eliminated this response, thus showing that it was due to ultra-violet light of wave-length less than 300 mμ in the second-order spectrum from the monochromator. When sporangiophores were exposed to ultra-violet light of wave-length 280 mμ, negative curvatures began to develop after about 5 min., and after 20–30 min. most of the sporangiophores had curved through at least 90°, pointing directly away from the light source.

To study this curvature further a + strain of *Phycomyces blakesleeanus* was grown on sterile potato dextrose agar in 10-ml. beakers; when young sporangiophores appeared the cultures were placed directly beneath a white light so that further growth was oriented vertically. Two or three hours before use they were transferred to dim red light. This procedure, based on earlier work with this fungus[1], was found to yield a reliable supply of straight sporangiophores.

Exposures of less than 2 min. to the ultra-violet give only small negative curvatures, so that continuous exposures were needed for precise analysis. Fig. 1 shows the development of negative curvatures upon continuous exposure to 280 mμ at an intensity of approximately 150 ergs/cm.²/sec. The shadowgraphs were taken 5 min. after the start of the exposure and at 10-min. intervals thereafter, by illumination from the side with a small bright source fitted with yellow filter. The curvatures are similar in general appearance and location to the positive curvatures obtained with continuous white light[2]; but in the present case the reaction is so vigorous that the curvatures usually attain magnitudes of 120° to 160°. At this angle the tips of the sporangiophores begin to receive the ultra-violet in the opposite sense from the original orientation, and as a result they curve rapidly upward, again overshooting the horizontal. With prolonged exposure they finally reach an equilibrium position close to the horizontal.

During this process the rotational component of the growth continues. In the first 20 min. the curvatures are usually 10–20° out of the plane of the light beam and the sporangiophore axis, and after 60 min. most of them exhibit a definite 'corkscrew' appearance. This behaviour contrasts with the positive curvature in visible light which has been considered to be unaffected by the rotation[3].

When the ultra-violet exposure is discontinued, the apical (growing) parts of the sporangiophores straighten up slowly, while the regions below the growth zone retain most of the curvature developed there. The straightening, which is primarily geotropic, indicates that the ultra-violet has not permanently damaged the growth system. This is confirmed by the fact that curvatures will rapidly develop in the opposite direction if the culture is rotated 180° at any time during the exposure to ultra-violet. The latter fact further implies that there is little adaptation to the ultra-violet, the sensitivity remaining high during many such reversals of position. It is only when the sporangiophores cease to grow altogether that they become insensitive to ultra-violet. Very young sporangiophores, lacking sporangia, respond to ultra-violet less strongly than mature ones, probably because they grow at a much slower rate. The intermediate stage, in which growth has ceased temporarily while the sporangium develops, does not respond.

The effective intensities are very low. A dose of about 0·06 erg/cm.²/sec. for 20 min. (at 280 mμ) sufficed for a threshold response (14° curvature in one case), while 2·0 ergs/cm.²/sec. was about the minimum needed to produce 90°. Thus the response is limited by intensity only over a narrow range, above which the system is effectively saturated.

Table 1. Curvatures after Continuous Exposure for 20 min. to Light of Various Wave-lengths

Wave-length (mμ)	Curvature (deg.)	Wave-length (mμ)	Curvature (deg.)
577	0	297	−20 to −30
546	0	289	−30 to −40
436	+10 to +20	280	−40 to −50
365	+1 to +10	265	−30 to −40
313	+1 to +5	248	−20 to −30
302	0	237	−30 to −40

The sensitivity of this system has complicated its quantitative study, but a rough action spectrum can be deduced from the data in Table 1. For this work mercury lines throughout the ultra-violet and visible were employed, at intensities below the saturating level. In general this involves an energy dosage steadily decreasing towards shorter wave-lengths. A glass filter was included in the system for wave-lengths greater than 310 mμ to eliminate scattered or second-order ultra-violet of short wave-lengths. Although these results do not quite take sufficient account of the relative energies at each wave-length, it seems clear that the response to ultra-violet is more sensitive than that to the visible and that the sensitivity is at a peak around 280 mμ, falling off at both sides and rising again at very short wave-lengths. The zero response at 302 mμ apparently represents a balance between positive and negative curvatures. The chemical nature of the material with peak absorption around 280 mμ remains unknown.

The question as to whether the negative curvature is correlated with an increase or a decrease in growth-

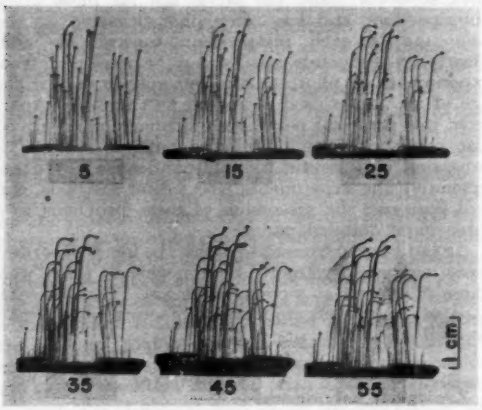

Fig. 1. The development of curvature in continuous ultra-violet. Time after beginning of exposure: left to right (upper row), 5, 15, 25; (lower row), 35, 45, 55 min. The source of light is to the left

rate (that is, a positive or negative 'light-growth reaction') was studied by illuminating with ultra-violet while rotating the culture, and afterwards following the growth-rate directly with a vertical travelling microscope. The results show clearly that exposure to 280 mμ, at doses which unilaterally would cause negative curvatures, temporarily promotes the growth-rate by 50–100 per cent. The negative curvature can therefore be ascribed to acceleration of growth on the near side, and a 'lens' effect such as that invoked to explain the positive curvatures[4] need not be postulated. Details of measurements of this interesting growth reaction will be published elsewhere.

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Flagellate-to-Amœba Transformation induced in *Tetramitus rostratus* by Nitrogen Mustard

Tetramitus is a coprophilic protozoon which displays flagellate, amœboid and cyst stages in its life-cycle. Previous investigators[1,2] have reported that reversible transformations between the amœboid and flagellate stages in this organism could be induced by environmental changes.

In a study of the factors involved in the changes from one stage to another, two monobacterial cultures of flagellates were isolated independently. Both these cultures have resisted all attempts to transform them back into the amœboid stage over a period of three and one-half years. These attempts included changes in oxygen tension, osmotic pressure, *p*H, temperature, lighting including ultra-violet, and changes in bacterial flora. Such environmental changes only led to a decreased rate of growth and multiplication up to complete cessation, with or without death of the culture as tested by washing and transplantation.

A striking change, however, took place when 48-hr. cultures of these flagellates (growing with *Escherichia coli* in a yeast–peptone–salt medium) were inoculated into the same medium containing one of the nitrogen mustards, methyl-*bis*(β-chloroethyl)amine hydrochloride (*HN2*). During the time of their contact with this compound, the flagellates showed neither multiplication nor transformation. With solutions containing more than 0·2 mgm./ml., inactivity and death resulted, commencing after 24-hr. exposure. Organisms that survived exposure (0·2 mgm./ml.) were washed and transferred to preconditioned media (media in which *E. coli* had been growing for 24 hr. offering a good food supply for *Tetramitus*). The flagellates recovered rapidly and multiplied for about three days (approximately seven generations), then transformed into the active and apparently healthy amœboid stage, which in turn could be propagated on yeast–peptone–agar slants. When transferred to broth cultures, this amœboid stage changed back into the flagellate stage, indicating that permanent injury to the transforming mechanism had not taken place.

More detailed investigation into the conditions necessary for methyl-*bis*(β-chloroethyl)amine hydrochloride to provoke this change in the organism showed that time of exposure to the drug was an important factor, about 48 hr. being necessary. Successful experiments were conducted with a concentration of 0·2 mgm./ml. at *p*H 5·10. As the *p*H was shifted towards the alkaline side, the experiments failed. This might have been due, in part, to the fact that this nitrogen mustard becomes rapidly unstable at a *p*H higher than 5·10, and thus may not have had sufficient time to provoke the biological change. Since it deteriorates slowly even at *p*H 5·10, it appears necessary for a sufficient concentration to be present at the start in order to maintain activity for at least 48 hr.

That nitrogen mustard acts on nucleic acid synthesis and perhaps in this way causes its effects on growth is well known; also accepted is the concept that transformations probably involve nuclear control. Perhaps components within the nucleus are capable of blocking certain cytoplasmic functions which mediate transformation. Nitrogen mustard, a known nuclear poison, could induce resistant flagellates to return to the amœboid stage (in two separate otherwise resistant cultures) by the destruction of such nuclear inhibitors. As a consequence, continued growth through seven generations after treatment may have lowered the concentration of the nuclear inhibitor(s) (not being replaced due to nuclear damage) and thereby enabled reversal to take place. In view of the above findings, it is suggested that components arise in the nucleus which render the organisms insusceptible to milder environmental changes ordinarily credited with causing transformation.

This work forms a part of a broader investigation of cyclic changes to be reported elsewhere.

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Production of an Antibiotic by Dermatophytes living in Horn Products

THE question whether or not soil-fungi capable of producing antibiotics produce such substances in their natural habitat has been much discussed. Many experiments have yielded contradictory results, but in these great deviation from natural conditions often occurred. However, the recent work of Wright[1], on the production of gliotoxin in soil to which a few pieces of wheat straw has been added, seems to be quite convincing.

It has been shown in our laboratories that the majority of dermatophytes cultivated from fungus diseases of the human skin are capable of producing

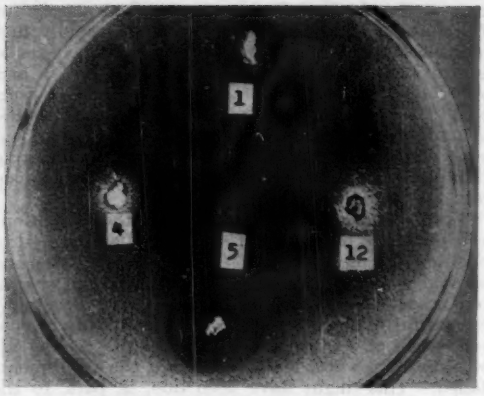

Fig. 1. Zones of inhibition caused by small pieces of skin infected with dermatophytes, originating from various patients

antibiotics. The isolation, from the ferment fluid of the shake culture of *Achorion* (*Microsporum*) *gypseum* of achoricins[2], and from that of *Trichophyton mentagrophytes* of *G*-(benzyl) penicillin[3], has already been reported.

It seemed worth examining whether or not antibiotics are produced by dermatophytes living as parasites in horn products and if so to clarify their nature. Epithelia and hairs with fungi were placed upon twenty-fold diluted nutrient agar containing a small number of *B. subtilis* 6633 spores. From 25 persons investigated, the horn products of 21 displayed an inhibition zone like that shown in Fig. 1. Epithelium from the skin, free of fungi, did not exert any inhibition. Small pieces of skin with confirmed antibiotic activity were placed upon agar containing penicillinase; here little or no inhibition zone was seen. This indicates that parasitic dermatophytes produce penicillin.

Pieces of skin producing zones of inhibition were removed from the nutrient agar, washed with oxytetracycline and then with sterile physiological saline. Then they were placed upon a culture medium for fungi, and strains of trichophytons and epidermophytons were grown. Examined in shake culture, these strains were found to be excreting antibiotic substances of high activity into the culture medium, and their effect was destroyed (or at least considerably reduced) by penicillinase. It may be concluded that dermatophytes in the skin produce penicillin and possibly other antibiotics also.

Our experiments indicate that antibiotics, particularly penicillin, are produced by skin-pathogenic fungi in their natural habitat. This fact offers an explanation of the allergic phenomena observed in the use of penicillin. Descriptions of the experiments are to be published in full elsewhere.

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Variability of Inbred and Incross Chickens

In mammals and in *Drosophila*, it has been found that F_1 incrosses are less variable than their parent inbred lines in respect of a number of characters[1]. In chickens, Shultz[2] has reported an average reduction of environmental variance in egg shape, November egg-weight, and shank-length, in eight F_1's between lines with relatively low degrees of inbreeding (F between 38 and 58 per cent).

Our studies on two highly inbred lines of White Leghorns and their F_1's, besides showing heterosis in growth-rate and other characters, have yielded data on variability of body-weight at different ages. Breeding stock of the two lines ($I : F \geqslant 98{\cdot}75$ per cent and $C : F \geqslant 98{\cdot}91$ per cent) were obtained from the National Poultry Institute Northern Breeding Station, Reaseheath, Cheshire. All four types of chicks were reared together, in each of the three hatches.

Data for I and $C \times I$ females at four ages are given in Table 1. Except at hatching, the coefficients of variation are consistently lower in $C \times I$, generally only about half as great as those in I. Data for males show a similar pattern. For various reasons we were unable to rear adequate numbers of C and $I \times C$, but the limited data on these two types show that C is even more variable than I, whereas $I \times C$ is similar to $C \times I$.

It is not surprising that there is little or no difference in variability between F_1 and inbred chicks at hatching, since both hatch from similar eggs.

Table 1

Age after hatching	Hatch	I				$C \times I$			
		No.	Body-weight (gm.)	Standard deviation (gm.)	Coefficient of variation (per cent)	No.	Body-weight (gm.)	Standard deviation (gm.)	Coefficient of variation (per cent)
0 weeks	*A*	8	33·38	2·46	7·37	10	32·25	2·98	9·25
	B	14	33·50	2·39	7·15	13	32·92	1·67	5·07
	C	22	29·68	2·16	7·29	26	30·77	2·11	6·87
3 weeks	*A*	8	122·88	11·21	9·12	10	157·20	9·72	6·18
	B	14	115·57	15·17	13·13	13	159·54	8·13	5·10
	C	22	77·86	12·81	16·45	26	119·77	8·53	7·13
6 weeks	*A*	8	236·50	27·27	11·56	10	362·80	24·43	6·73
	B	14	209·57	33·29	15·89	13	350·69	23·42	6·68
	C	22	209·82	28·57	13·62	26	326·96	23·94	7·32
12 weeks	*A*	8	610·50	37·83	6·20	10	896·00	50·21	5·60
	B	14	596·93	72·54	12·15	13	927·69	51·74	5·58
	C	22	606·59	61·36	10·12	26	870·08	37·99	4·37

Although chicks were weighed at intervals during the first three weeks of life, our data are insufficient to show clearly how early during this period the lower variability of the F_1's develops. Beyond twelve weeks of age, there is a tendency for inbred variability to subside towards the F_1 level. Data are being collected on age at production of first egg; these are not yet complete, but it is already clear that the reduction of variability in the F_1's is at least as great in this character as it is in body-weight between three and twelve weeks (cf. Yoon[3]).

These and other data on $C \times I$ (including a batch reared at the demonstration farm of British Oil and Cake Mills, Ltd., Stoke Mandeville, Bucks) indicate that they have a level of variability considerably lower than that usually found in commercial strains of chickens. Uniformity in body-weight does not necessarily imply uniformity in other characters, and uniformity, although important, is not the sole criterion of usefulness in experimental animals. Nevertheless, the low variability of these incrosses between the Reasceheath lines does suggest their possible value to those who use chickens for bio-assay and other quantitative experiments. With the help of Dr. W. Lane-Petter, of the Medical Research Council Laboratory Animals Bureau, arrangements have been made for a number of laboratories to compare the variabilities, in characters and responses of particular interest to them, of incross chicks from Reasceheath stock with those of chicks from their normal sources of supply. Comparative tests planned for this year include assays of vitamin D, folic acid and thyrotrophic hormone, production of bacterial antibodies, and infections with *Ascaridia lineata*, *Eimeria* spp. and *Plasmodium gallinaceum*.

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Host–Parasite Specificity in a Braconid, *Apanteles glomeratus* L.

CUSHMAN[1] pointed out that a given parasite species may attack two or more hosts that are widely separated taxonomically but have the same relationship to the plant, whereas closely related species, but of different habit, are not subject to attack. He also stated that the relationship of host insects to the plant, rather than taxonomic relationship, in the case of many Braconidae and various other parasitic groups, often governs the choice of hosts by the parasite. Gahan[2] concludes that, apart from the Eupelmids, most of the Chalcidoids seem to be guided by the character of the plant and the location of possible hosts in it, rather than by taxonomic relationship of the species attacked. Salt[3], in his experimental studies in insect parasitism, concludes that it is certain that some parasites are first attracted not to a particular host but to a certain type of environment. Laing[4] divides the qualities which influence the parasite into two kinds: factors connected with the environment and factors pertaining to the host. He states that the parasites are attracted by the physical and chemical factors characteristic of different types of environment, and the parasite, having entered the environment, appears to search systematically through it to perceive its host.

The caterpillars of *Pieris brassicae* L. and *Mamestra brassicae* L. are the two common pests in gardens in Great Britain and Ireland, feeding chiefly upon various kinds of cabbage. Adults of the two species appear in May and June. The early larval stages of *Pieris* and *Mamestra* not only have the same relationship to the plant, but also they are under the same environmental conditions. They are living in a typical host-containing area for the braconid parasite *Apanteles glomeratus* L. The young caterpillars of *Pieris brassicae* L. are always subject to the attack of the female *Apanteles glomeratus*, but those of *Mamestra* are immune.

Faure[5] recorded the following species as suitable hosts for the parasite *Apanteles glomeratus*: *Pieris brassicae*, *P. rapae* L., *P. daplidice* L., *P. monuste* L., *Aporia crataegi* L., *Vanessa urticae* L., *Macroglossa stellatarum* L., *Smerinthus populi* L., *Notodonta ziczag* L., *Zygaena ephialtes* L., *Abraxas grossulariata* L., *Phigalia pedaria* L., *Bembecia hylaeiformis* L., *Porthetria dispar* L., *Euproctis chrysorrhea* L., *Phylctaenia ferruginalis* Hbn., *Lymantria monacha* L. and *Liparis auriflua* L. Moss[6] stated that *Apanteles glomeratus* L. is recorded in the Parasitic Catalogue of Farnham House Laboratory from nearly fifty species of Lepidoptera.

I was able to get the female *Apanteles* to oviposit in the youngest larvæ of *Mamestra brassicae* bred from eggs collected from cabbage plants. *Apanteles* eggs do not develop inside the body of the *Mamestra* caterpillar, and therefore the cabbage moth is not recorded as a host for this parasite. The reason for this is unknown, but the fate of *Apanteles* eggs has now been followed out.

In Fig. 1 is shown an egg of *Apanteles* inside the larva of *Pieris brassicae*. The eggs lie in the subdermal tissues and general body cavity and provoke no cellular reaction from the host tissue. In the case of the eggs laid in *Mamestra*, after a few hours (4 hr. in the case of Fig. 2) the eggs become the focus of wandering hæmocœl cells which form a palisade around them. A few hours later (12 hr. in the case of Fig. 3) the eggs are surrounded by a large number

of these cells, which finally cause death and pycnosis of the segmenting nuclei of the *Apanteles* eggs.

First-, second- and third-larval stages of *Mamestra* were introduced to the *Apanteles* females in a glass tube. This procedure was carried out under laboratory conditions, and with the absence of *Pieris* caterpillars or any other host recorded for this parasite. Under these conditions, the female wasp was stimulated by the presence of *Mamestra* larvæ, and the parasite behaved normally as if it were attacking a *Pieris* caterpillar. The defensive reflexes carried out by the attacked *Mamestra* larva were also the same as those seen during an attack on the *Pieris* caterpillar, and in most cases the former showed less resistance. It is not known whether *Mamestra* is attacked under natural conditions by *Apanteles*.

Considering the wide distribution of this polyphagous parasite and its large number of hosts, which are separated taxonomically and by different habit, it can be stated that the parasite's choice of a host in the case of *Apanteles glomeratus* L. does not depend mainly on the characters of the plant and the location. This view seems to be confirmed by the case of *Mamestra*. The other point emphasized by this work on *Mamestra* is that the host–parasite specificity depends actually on the suitability of the host for the development of the parasite.

I wish to thank Prof. J. Brontë Gatenby for suggesting this work.

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Bone Marrow Volume in Guinea Pigs

For quantitative studies of hæmopoiesis[1], it is important to know both the absolute count of cells per unit volume of bone marrow and also the volume of the marrow as a whole. From a review of the literature it appears that whereas in man and in a few laboratory animals a small number of determinations of marrow volume have been made, none has been made in the guinea pig. Since this latter animal is the one on which in our own laboratory a number of quantitative studies of hæmopoiesis are in progress, it has become necessary to determine its marrow volume with as much accuracy as possible. The following is a summary of my observations.

The method used was that of measuring the volume of marrow spaces in the macerated skeleton by means of density bottles. After the volume of the bone substance had been measured, the skeleton was boiled in saturated agar solution under reduced pressure and the agar induced to set, thus filling all the spaces in the interior. The total volume was then measured, the increase over the first measurement representing the volume of agar taken up, and hence, after correction for agar occupying spaces which would not normally contain marrow, the volume of the marrow spaces. The agar uptake per unit weight of marrow-free bone was reasonably constant for the same skeleton, whatever site it was taken from. Validation experiments on bones where the fresh marrow could be measured indicated that the above method gave a reliable estimate of marrow volume. It is a development of the agar method of Nye[2] but is of much greater accuracy.

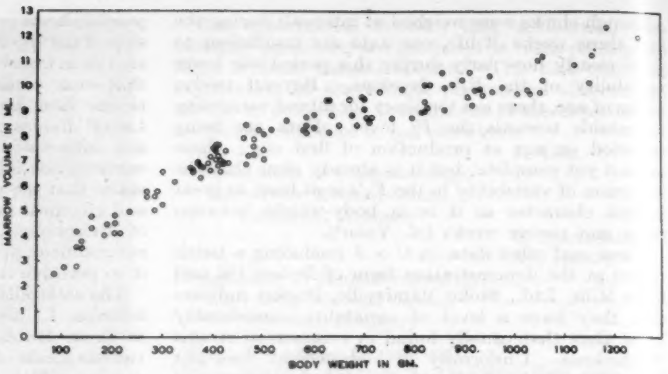

Fig. 1. Relationship between body-weight and marrow volume in the guinea pig

For our marrow investigations we normally use male guinea pigs of the Dunklin–Hartley strain the body-weights of which lie between 350 and 450 gm. (approximately eight weeks old). The mean marrow volume of twenty-five guinea pigs of this weight-range was 7·014 ml. and the standard deviation was 0·358 ml.

Marrow volume measurements were made in 120 guinea pigs with body-weights ranging from 85 to 1,250 gm. (one week to more than a year old) and the results are shown in Fig. 1. There was a linear relationship between marrow volume and the logarithm of the body-weight, the regression coefficient being 7·885 ($s = 0·171$). Approximately half the marrow was in the limb bones, a fifth in the skull and the rest in the trunk.

For our quantitative hæmopoietic studies, one also wished to know what proportion of the total marrow was formed by red marrow. The skeletons of fifteen newly killed guinea pigs of the 350–450 gm. group were therefore examined and fatty marrow was shown to be symmetrically and centrifugally distributed, being confined to the periphery of the limbs and coccyx, thus recalling the observations of Neumann[3] on humans. Red marrow occupied all the other bones, including those of the skull and trunk. There were relatively sharp junctions between red and fatty marrow in the tibia, radius and ulna, as shown in other animals by Huggins and Blocksom[4]. Cell counts and microscopic sections bore out the naked-eye appearances.

These observations permitted the volumes of red and fatty marrow to be determined separately in another series of guinea pigs. The limbs of one side were used for determining the sites of junction, and then the bones of the opposite side, appropriately transected, were submitted together with skull and trunk bones to maceration and marrow-volume estimation.

In twelve animals of this 350–450 gm. group the mean red marrow volume was 6·249 ml. ($s = 0·446$ ml.), representing 89 per cent of the total marrow or approximately one-third of the liver, the mean weight of which was 20 gm.

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A Method of destroying a Malignant Rat Tumour *in vivo*

A HYPOTHESIS of tumour formation based on the catalase–hydrogen peroxide mechanism in living cells was published recently[1] following observations on abnormalities occurring in aerobic and anaerobic bacteria due to certain respiratory irregularities[2]. If this hypothesis be correct, then a logical assumption is that agents which inactivate catalase or produce hydrogen peroxide (or free radicals) should have a detrimental effect on tumours.

The treatment of experimental tumours with the catalase inhibitor sodium azide is effective[3]. Ionizing radiations have long been known to destroy malignant cells, and this may be explained as being due to the production in the presence of oxygen, in fluid systems, *in vivo*, of hydrogen peroxide, the free powerful oxidizing radicals, HO_2, HO, and atomic oxygen[4] as well as the destruction of the enzyme catalase[5].

Hydrogen peroxide has been given by daily intraperitoneal injections in animals carrying tumours, without effect[6]. Makino and Tanaka[7], however, observed temporary retardation of ascites sarcomas in rats on intraperitoneal injection of 1 ml. of 2 per cent hydrogen peroxide and Hollcroft and Lorenz[8] noticed some improvement of lymphoid tumours in mice after the intravenous injection of hydrogen peroxide. Worrall[9] mentions the use of peroxide-forming compounds in animals and humans in an attempt to set up catastrophic reactions in cancer cells.

It seemed to me that the only effective way to destroy the malignant cells which are already deficient in catalase[10] and sensitive to over-oxidation is to keep up a continued administration of an active oxidizing agent. Since hydrogen peroxide is an excellent ionizing solvent, and since it is formed and is obviously of great fundamental importance in most living cells, this agent appears to be the one of choice.

Rats implanted with the Walker 256 adenocarcinoma were treated by simply replacing their drinking water with dilute solutions of commercial hydrogen peroxide (Laporte Chemicals, Ltd., London), and maintaining them on a normal diet. The optimal concentration has been found to be 0·45 per cent by weight and with the rats being housed in metal cages (ten animals per cage) the rate of cure is on the average 50–60 per cent. The time taken for complete disappearance of the tumour is usually 15–60 days. This, of course, depends on the size of the tumour when treatment is started. So far, 72 rats have been cured; they are now back on tap water and normal diet, and will be maintained in this manner for the rest of their natural lives. Ten of these rats have been cured for more than two months; their condition is excellent and there is no sign of recurrence of the tumour.

This treatment has recently been used in four humans with very advanced inoperable tumours. In two of the cases there has been marked clinical improvement with decrease in size of the liver (which contained metastases) and progressive diminution in the blood serum polysaccharide which Keyser[11] has shown to be an indication of effective therapy in neoplastic states.

A detailed account of these experiments will be published shortly.

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A Simple Method for staining Mitochondria

EXCELLENT methods for staining mitochondria have been available for many years, but nearly all demand experience and skill. In the course of a general study of the use of osmium tetroxide in the fixation and staining of tissues, which will be published in full elsewhere[1], I have had occasion to re-investigate the use of gallic acid derivatives in the visualization of osmium[2,3]. Treatment with tannic acid or pyrogallol after osmium tetroxide fixation provides a useful method for staining droplets of neutral fat; but the osmium taken up by the mitochondria, the nuclear membrane, nucleolus, ergastoplasm, etc., is less readily revealed. I have found that it can be made visible by prolonged treatment with alkyl esters of gallic acid, notably ethyl gallate.

Small pieces of tissue are fixed at 0°–4° C. for several hours in 1 per cent osmium tetroxide buffered at *p*H 7·25 with veronal acetate buffer in isotonic sodium chloride[4,5]. They are then transferred to a saturated solution of ethyl gallate in 0·25 per cent cresol for twenty-four hours or longer. The tissue now resembles a small piece of coal. It may be embedded in 25 per cent gelatin and cut frozen, or embedded in paraffin (through cedar wood oil) and the sections mounted in Farrants's medium containing ethyl gallate, or in cedar wood oil containing nonyl gallate. But the simplest procedure is to embed in polyethylene glycol wax of suitable hardness, to cut at 0·5–2μ, float on water and mount the sections individually in glycerine jelly to which ethyl gallate has been added.

As a method for mitochondria this is extremely simple, gives invariably reproducible results, and requires neither skill nor experience. Fig. 1 shows

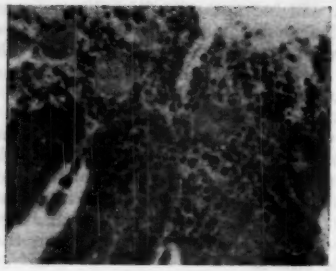

Fig. 1

as an example a section of mouse liver. The droplets of neutral fat (rather few in this section) stain an intense blue, appearing black in layers a few microns thick, the mitochondria grey or blue-grey.

V. B. Wigglesworth

Department of Zoology,
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April 1.

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Use of Antipyrene and N-Acetyl 4-Aminoantipyrene in the Measurement of Body Water and the Intraluminal Water of the Gastro-intestinal Tract of Living Cattle

It was demonstrated recently that a knowledge of the water content of the empty body allows the entire proximate composition and the calorific value of the bodies of cattle[1] and pigs[2] to be resolved by means of the well-known inverse relationship between the fat and water contents of the animal body. Indirect methods of measuring body-water have, therefore, a potentially great usefulness in nutritional experiments.

Experiments with eleven cows confirmed that the commonly used reference substance antipyrene is metabolized by the body, less than 2 per cent of doses injected intravenously appearing in the urine in 50 hr. The theoretical distribution in blood at the time of the injection may, however, be calculated by extrapolation from the concentrations in samples of blood taken after distribution in body-water is complete, and the body-water content or space is then readily determined. The same method may also be used with N-acetyl 4-aminoantipyrene as the reference substance. The experiments confirmed that this compound is not metabolized, $99{\cdot}5 \pm 1{\cdot}79$ per cent of the injected dose being excreted in the urine in 50 hr. In consequence, the body-water content at any given time after injection could also be found by an alternative method[3] requiring only single determinations on blood and urine. The two compounds proved compatible in solution, and with certain refinements each could be determined in the presence of the other in blood, urine or digesta by the methods of Brodie[4].

In the course of these experiments, it was observed invariably that values for the water content of animals was greater when using antipyrene than when using N-acetyl 4-aminoantipyrene. The difference was approximately equal to the amount of water to be expected in the gut, suggesting that antipyrene might become distributed in the total body-water and N-acetyl 4-aminoantipyrene in only the empty body-water.

This hypothesis was examined with two steers and two cows each equipped with a rumen cannula and consuming rations of hay, grass or hay and concentrates and with liveweights ranging from 325 kgm. to 680 kgm. The weight of water in the reticulo-rumen was measured by temporary removal of the contents, and from this value the water content of the whole gut was determined assuming that 73 per cent of the gut water is found in this compartment[5]. Examination of rumen contents also showed that the diffusion of antipyrene into the gut was very much more rapid than that of N-acetyl 4-aminoantipyrene. The results (Table 1) showed that when allowance was made for the amounts of the marker entering the gut, the difference between the water spaces for the two reference substances closely approached the value for the amount of water in the gut.

Table 1. Estimates of the Intraluminal Water of the Gastro-intestinal Tract

Animal	Difference between water space for the two reference substances		Water in total tract calculated from amount found in reticulo-rumen (kgm.)
	Uncorrected (kgm.)	Corrected for amount of reference substance entering tract (kgm.)	
Steer *A*	46·8	55·0	53·6
Steer *B*	75·1	92·4	90·8
Cow *K*	51·1	64·4	65·2
Cow *K*	47·9	65·1	66·2
Cow *D*	69·0	80·3	82·0

These studies encourage the hope that concurrent use of two reference substances will allow the water content to be determined simultaneously in the whole body, the empty body and in the contents of the alimentary canal. They are being continued in an attempt to derive means of making allowance in non-fistulated animals for the amounts of the reference substances entering the gut.

This work was largely carried out while one of us (J. T. R.) was on leave from Cornell University; the award of the John Simon Guggenheim Memorial Foundation that made this possible is gratefully acknowledged. We also wish to thank Mr. D. Millard and Mr. V. W. Johnson for their help with the experiments.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, May 20

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5 p.m.—Dr. E. J. Hewitt: "Micronutrient Element Metabolism in Plants".* (Further lectures on May 27 and June 3.)

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE, PHILOSOPHY OF SCIENCE GROUP (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. J. R. Smythies: "The Notion of an Image Space".

INSTITUTION OF MECHANICAL ENGINEERS (joint meeting with the INSTITUTION OF CIVIL ENGINEERS and the INSTITUTION OF ELECTRICAL ENGINEERS, at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Report on "Hydroelectric Projects in the U.S.S.R.".

INSTITUTE OF METAL FINISHING (at the Northampton Polytechnic, St. John Street, London, E.C.1), at 6.15 p.m.—Dr. R. W. Cahn: "The Use of Radio-Isotopes in Metal Finishing Research".

Tuesday, May 21

UNIVERSITY OF LONDON (in the Clinical Lecture Theatre, Middlesex Hospital Medical School, Mortimer Street, London, W.1), at 4 p.m.—Dr. R. F. Milton: "Trace Elements in the Biological Relationships of Soil, Plant and Animal".*

MEDICAL RESEARCH COUNCIL (at the National Institute for Medical Research, Mill Hill, London, N.W.7), at 5 p.m.—Dr. Paul C. Zamecnik (Massachusetts General Hospital, Boston): "Recent Studies on Protein Synthesis".

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.15 p.m.—Prof. A. von Muralt (Berne): "Research at the Jungfraujoch Scientific Station".* (First of two Halliburton Lectures.)

INSTITUTION OF CIVIL ENGINEERS (at Great George Street, Westminster, London, S.W.1), at 5.30 p.m.—Mr. C. S. Chettoe and Mr. Wm. Henderson: "Brick and Masonry Arch Bridges: an Investigation".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5.30 p.m.—Sir Lawrence Bragg, F.R.S.: "Famous Experimenters in the Royal Institution". (Lecture for Fourth Form Pupils. Further lecture on May 28.)

UNIVERSITY OF LONDON (in the Chemistry Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. Sir Cyril Burt: "The Inheritance of Mental Ability"* (Walter Van-Dyke Bingham Lecture).

SOCIETY FOR WATER TREATMENT AND EXAMINATION (joint meeting with the INSTITUTION OF PUBLIC HEALTH ENGINEERS, at Caxton Hall, Westminster, London, S.W.1), at 6 p.m.—Mr. W. G. Carey: "The Chemist and the Public Health Engineer in relation to Water Treatment and Examination".

SOCIETY FOR ANALYTICAL CHEMISTRY, PHYSICAL METHODS GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Meeting on "Electrochemistry". Dr. L. E. Smythe: "Coulometric Titrations with an Integrated Current Source"; Mr. A. W. Gardner: "Pulse Polarography".

SOCIETY FOR VISITING SCIENTISTS (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion Meeting on "Taste and Smell". Dr. H. Kalmus: "The Physiology and Genetics of Taste and Smell"; Mr. B. Babington Smith: "The Experimental Study of Preference"; Mr. W. J. Gleeson: "Some Practical Aspects of Taste Testing".

Wednesday, May 22

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.15 p.m.—Prof. A. von Muralt (Berne): "Chemical Aspects of Nervous Excitation".* (Last of two Halliburton Lectures.)

EUGENICS SOCIETY (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. C. M. Stewart: "Population Problems in the British Caribbean".*

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (at 14 Belgrave Square, London, W.1), at 6 p.m.—Scientific Papers (Fifth Young Members' Meeting).

BRITISH INSTITUTION OF RADIO ENGINEERS (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Mr. G. Campbell: "Barium Titanate and Its Uses as a Storage Device".

Wednesday, May 22—Thursday, May 23

IRON AND STEEL INSTITUTE (at 4 Grosvenor Gardens, London, S.W.1)—Eighty-eighth Annual General Meeting.

Thursday, May 23

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Annual General Meeting. 6.30 p.m.—Dr. A. D. Booth: "General Applications of Digital Computers".

Thursday, May 23—Friday, May 24

ROYAL METEOROLOGICAL SOCIETY (joint meeting with the ROYAL ASTRONOMICAL SOCIETY, at Burlington House, Piccadilly, London, W.1), at 10.30 a.m. daily—Symposia on "Planetary Atmospheres and Convection in Rotating Fluids".

Friday, May 24

BIOCHEMICAL SOCIETY (in the Department of Biochemistry, Physiology Institute, Newport Road, Cardiff), at 2 p.m.—Scientific Papers.

ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN (at 16 Princes Gate, Kensington, London, S.W.7), at 7 p.m.—Dr. Gotthard Wolf (Göttingen): "Factual Reliability in Scientific Films".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. Harold Heywood: "Solar Energy—a Challenge to the Future".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

DEMONSTRATOR IN THE DEPARTMENT OF CHEMISTRY—The Registrar, King's College, Newcastle-upon-Tyne (May 24).

GRADUATE DEMONSTRATOR IN PARASITOLOGY, to carry out research, preferably in helminth physiology, in addition to light teaching duties—The Registrar, The University, Glasgow, W.2 (May 25).

LECTURERS (preferably with a special knowledge in one of the following fields: electrical machinery; control systems; electro-acoustics and vibration analysis; and electrical communications, including microwaves) IN ELECTRICAL ENGINEERING—The Secretary of University Court, The University, Glasgow (May 25).

ASSISTANT LECTURER IN AGRICULTURE AND DEPUTY FARM DIRECTOR; an ASSISTANT LECTURER (with a special knowledge of crop husbandry) IN AGRICULTURE; and a DEMONSTRATOR IN AGRICULTURE, to assist with experimental work on the university farms—The Registrar, The University, Leeds 2 (May 27).

READER IN ANATOMY at the London Hospital Medical College—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 27).

RESEARCH ASSISTANTS (2) IN THE FIELDS OF INORGANIC AND PHYSICAL CHEMISTRY, respectively—The Secretary, The University, Exeter (May 27).

READER IN GEOGRAPHY at Birkbeck College—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 29).

ASSISTANT LECTURER IN GEOGRAPHY; and an ASSISTANT LECTURER IN CHEMISTRY—The Registrar, The University, Leicester (May 31).

ASSISTANT (with a good honours degree in agricultural zoology or zoology) IN AGRICULTURAL ZOOLOGY—The Secretary of University Court, The University, Glasgow (May 31).

LECTURER (qualified in the physical sciences, preferably chemistry, and varied teaching experience) IN THE DEPARTMENT OF EDUCATION—The Registrar, The University, Leicester (May 31).

ORGANIC CHEMIST (with a first- or good second-class honours degree) with the Agricultural Research Council's Plant Growth Substance and Systemic Fungicide Unit, at Wye College (University of London), near Ashford, Kent—The Director, Plant Growth Substance and Systemic Fungicide Unit, Wye College, near Ashford, Kent (May 31).

PRINCIPAL OF THURROCK TECHNICAL COLLEGE, Grays—The Chief Education Officer, County Offices, Chelmsford, Essex (May 31).

SENIOR LECTURERS (2) IN PHYSICS at Auckland University College (University of New Zealand)—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, May 31).

SENIOR RESEARCH WORKERS (2) (with considerable research experience) IN THE AGRICULTURAL RESEARCH COUNCIL'S POULTRY RESEARCH CENTRE, Edinburgh, to investigate problems concerning the growth and reproduction in the domestic fowl with reference to the importance of endocrine mechanisms—The Secretary, Agricultural Research Council, Cunard Building, 15 Regent Street, London, S.W.1 (May 31).

RESEARCH FELLOW, and a RESEARCH ASSISTANT IN THE DEPARTMENT OF BOTANY, to undertake a survey of the nutritive requirements of the excised roots of different species and varieties—The Registrar, University College, Singleton Park, Swansea (June 1).

ASSISTANT LECTURER IN PHYSICS—The Secretary, The Queen's University, Belfast (June 3).

LECTURER or ASSISTANT LECTURER IN APPLIED MATHEMATICS—The Registrar, University College of North Staffordshire, Keele, Staffs (June 3).

LECTURER or ASSISTANT LECTURER IN MATHEMATICAL STATISTICS—The Registrar, The University, Manchester 13 (June 3).

RESEARCH FELLOW IN MATHEMATICS; and an ASSISTANT IN MATHEMATICS—The Secretary of University Court, The University Glasgow (June 7).

ASSISTANT LECTURER or LECTURER (with special interest and qualifications in sedimentary petrology and a general interest in stratigraphy) IN GEOLOGY—The Secretary, University College, Gower Street, London, W.C.1 (June 10).

ASSISTANT LECTURER (with an honours degree) IN CHEMISTRY at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (June 14).

READER IN ANTHROPOLOGY at the London School of Economics and Political Science—The Academic Registrar, University of London, Senate House, London, W.C.1 (June 14).

CHAIR OF CHEMISTRY in the University College of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (June 15).

CHAIR OF PHILOSOPHY in the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, June 15).

LECTURER (with a special interest in mycology and plant pathology) IN BOTANY at the University College of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (June 18).

LECTURERS (2) (with specialist design and construction experience) IN CONCRETE TECHNOLOGY—Prof. A. L. L. Baker, Imperial College, London, S.W.7 (June 30).

BENGER RESEARCH FELLOW (graduate in medicine or science (including pharmacy)) IN PHARMACOLOGY—The Registrar, The University, Manchester 13 (July 1).

RESEARCH STUDENTS (with the degree of Bachelor or Master of a British university, other than Manchester) IN SCIENCE—The Registrar, The University, Manchester (July 1).

ASSISTANT BIOCHEMIST (with considerable experience of routine biochemical procedures and research work) IN THE PATHOLOGY DEPARTMENT—The Director of Pathology, Royal Women's Hospital, Melbourne, N.3, Australia.

ASSOCIATE OR FULL PROFESSOR (with an advanced degree and preferably both industrial and research experience) OF ELECTRICAL ENGINEERING—Prof. G. A. Wallace, McGill University, Montreal, Canada.

ENTOMOLOGIST (preferably with an interest in insect population studies and/or the physiology of insect reproduction) IN THE TECHNOLOGICAL IRRADIATION GROUP at the Wantage Radiation Laboratory to assist in research into the application of ionizing radiations to insect control—The Group Recruitment Officer, Atomic Energy Research Establishment, Harwell, Didcot, Berks, quoting 783/34.

GEOCHEMIST (with a good honours degree in chemistry or equivalent, and some experience in inorganic analysis, with special reference to rock and mineral analysis, and preferably with postgraduate experience) IN THE GEOLOGICAL SURVEY DEPARTMENT, Government of Tanganyika, for the analysis of rocks, minerals and ores, and the supervision of junior staff in routine analytical work—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.105/8/09.

LECTURER (man or woman) IN CHEMISTRY—The Warden, Goldsmiths' College (University of London), New Cross, London. S.E.14.

MASTER TO TEACH CHEMISTRY to scholarship level—The Headmaster, Queen Elizabeth's Grammar School, Blackburn.

MASTER TO TEACH MATHEMATICS to scholarship and advanced level—The Head Master, Harrow School, Harrow, Middlesex.

RESEARCH ASSISTANT (BIOCHEMIST or BIOLOGIST), for work on problems of nutrition and fertility, involving chiefly experiments with laboratory animals—The Secretary, Queen Elizabeth College (University of London), Campden Hill Road, London, W.8.

RESEARCH ASSISTANT (B.Sc. standard) IN THE CHEMICAL RESEARCH LABORATORY, for work in the steroid field—The Secretary, Sheffield No. 1 Hospital Management Committee, Nether Edge Hospital, Sheffield 11.

RESEARCH ENTOMOLOGIST (with at least a second-class honours degree in entomology and two or more years postgraduate training or experience, preferably in insecticidal control) IN THE DEPARTMENT OF AGRICULTURE, Nyasaland, to carry out research into the control of red bollworm and cotton stainer—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.87/4/01.

SENIOR LECTURER IN MATHEMATICS—The Secretary, Royal College of Science and Technology, Glasgow.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

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National Research Development Corporation. Report and Statement of Accounts for the year 1st July, 1955 to 30th June, 1956. Pp. ii+16. (London: H.M. Stationery Office, 1957.) 1*s.* net. [253

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Royal Astronomical Society. Occasional Notes. No. 19, Vol. 3, January 1957: Close Binary Stars. By Otto Struve and Su-Shu Huang. Pp. 161–188+plates 17–19. (London: Royal Astronomical Society, 1957.) 4*s.* 6*d.* [263

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Smithsonian Institution: Bureau of American Ethnology. Seventy-third Annual Report of the Bureau of American Ethnology to the Secretary of the Smithsonian Institution, 1955–1956. Pp. ii+23+2 plates. Bulletin 161: Seminole Music. By Frances Densmore. Pp. xxviii+223+18 plates. 1 dollar. Bulletin 162: Guaymi Grammar and Dictionary, with some Ethnological Notes. By Ephraim S. Alphonse. Pp. ix+128. 65 cents. (Washington, D.C.: Government Printing Office, 1956 and 1957.) [293

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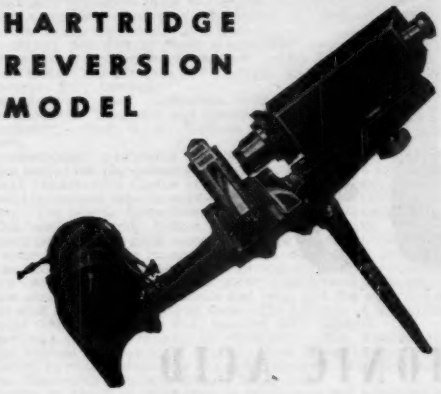

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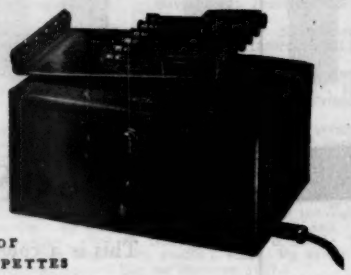

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